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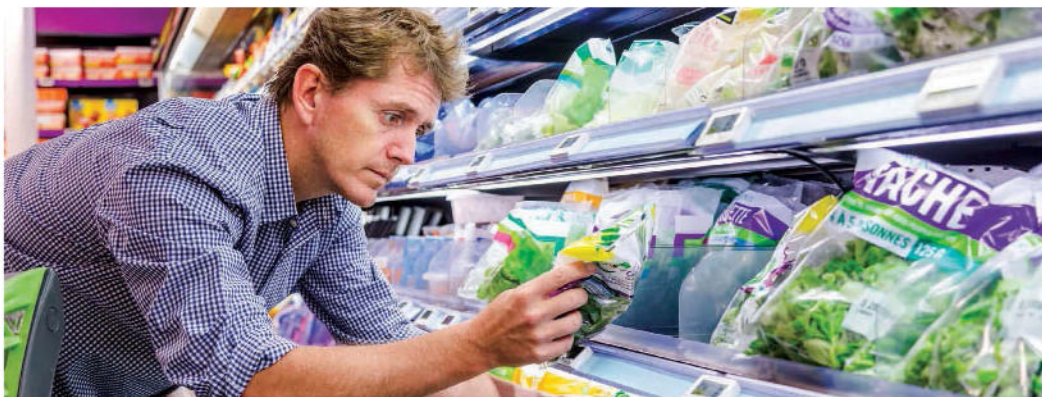
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PHANIE / ALAMY

Warning: contains rubbish

Food labelling rules are letting consumers down

EATING healthily has never been especially easy, but at least the rules were straightforward: cut down on fat, get most calories from carbs and eat five portions of fruit and vegetables a day.

In recent years, though, those simple rules have become more complicated. Saturated fat, for example, may not be as unhealthy as we once thought. Avoiding it may drive us to unwittingly eat more sugar.

Amid the confusion there was always the five-a-day rule to fall back on. But even that is now being sliced, diced and mashed. A long and deliberate process of “de-bittering” has made fruit and veg tastier, but stripped them of some of their most valuable nutrients

(see page 26). They are still a healthy option, but may be less so than we have been led to believe.

It is easy, but unfair, to blame the food industry. Growers and retailers are only responding to consumer demand. But how many consumers have heard of de-bittering? Can you demand something you don't know about? The real culprit is a lack of reliable information, fuelled by well-meaning but counterproductive rules on food labelling.

This problem is exposed by what happens when the industry introduces a variety such as Beneforté broccoli, bred to be high in a nutrient with proven anticancer properties. But when retailers want to trumpet this fact,

they find their hands are tied. Instead of giving evidence-based information, they have to use science-lite slogans such as “Naturally high in the plant nutrients, glucosinolates, with an exquisite sweet flavour.” That is the worst of all worlds, equating healthfulness with sweetness – the opposite of what is going on in other fruit and veg.

Food labelling rules are guided by the belief that consumers are incapable of understanding nuanced scientific information. That is patronising and past its sell-by date. It is surely better to risk blinding people with science than bamboozling them with empty and misleading marketing messages. ■

The jilted generation

MILLENNIALS – those born between 1980 and 2000 – are nominally the generation that can have it all: a good education, a fulfilling career, a home of their own, a packed social calendar and a perfect partner courtesy of online dating. In reality many are struggling. Weighed down by debt, unable to afford a decent home and finding it hard to get a career going, many feel that, far from

having it all, they have nothing.

No wonder many are putting off plans to start a family. But there's bad news on that front too, especially for women (see page 6). Fertility doesn't last forever. IVF isn't a saviour. Wait too long to have children and you are at greater risk of a difficult birth and having a child with a genetic disorder.

The difficulties facing this

generation are mostly not of their own making. The middle-aged politicians and employers who make decisions that affect them also seem to have been seduced by the idea that IVF is a get-out-of-jail card that allows people to endlessly defer life's biggest decision.

Their generation didn't have it easy, either. But by recognising the limitations of reproductive technology they could make life easier for those they will come to rely on in their old age – and give them grandchildren. ■



Now you see it, now you don't...

Tiger reality check

WHERE have Bangladesh's tigers gone? Or were they even there in the first place? A census has reportedly estimated that there are only 106 tigers in the country's famed Sundarbans mangrove forest – a dramatic fall from the previous survey result of 440 in 2004.

But there is a possibility that the earlier study based on paw-print evidence may have overestimated tiger numbers. The latest survey, which is based on camera-trap evidence, should give a much more realistic and therefore more valuable figure. "It sounds like terrible news, but the critical thing is that Bangladesh has now carried out a survey using robust methodology," says Richard Thomas, who is wildlife coordinator for TRAFFIC UK, a group

that monitors trade in wildlife products. "So now we have accurate baseline data enabling us to judge much better what the true picture is."

News of the latest survey, which has yet to be published, appeared in a story by AFP. It reported Tapan Kumar Dey, the Bangladeshi government's wildlife conservator, saying that the year-long camera-trap survey ended in April and estimated that there were between 83 and 130 tigers, giving an average of 106. Population updates from Bhutan and Malaysia were also expected this week. The World Wildlife Fund says that there are now around 3200 wild tigers, down from 100,000 a century ago. Tigers used to roam across most of Asia, but are now restricted to just 7 per cent of their original range.

Another Earth?

MEET Kepler-452b, Earth's new alien cousin. This rocky planet is the first Earth-sized alien world we have seen that circles a sun-like star at a distance that should allow liquid water to exist on its surface.

"Models suggest that water could have existed on the planet's surface for longer than Earth has existed"

The planet came to light after a first pass through the full data set collected during the NASA Kepler telescope's four-year run. The analysis also yielded 11 other candidate worlds close to the size of Earth in the habitable zone around their stars.

But 452b is in an Earth-like class by itself. The planet's star, about 1400 light years away in the constellation Cygnus, is just slightly bigger than our sun. Even the planet's year is familiar at 385 days long.

That still doesn't make Kepler-452b a perfect Earth analogue. It is 60 per cent larger than Earth, and probably weighs about five times

as much. This extra mass might drive enduring volcanic activity.

Geological models suggest that it would have a rocky composition and a thick atmosphere. And although the planet's host star resembles the sun, it is about 1.5 billion years older. That means the star is hotter, perhaps causing 452b to have a runaway greenhouse effect that would make it inhospitable to life.

Yet models of the star and planet suggest that water could have existed on 452b's surface for 6 billion years – longer than Earth has existed.

Vaccine for MERS

BREATHE easy, the South Korean public were told on Tuesday. The outbreak of respiratory virus MERS is over. There have been no new cases for 23 days, so the prime minister urged people to resume "normal daily activities".

The outbreak infected 186 people, killing 36. There are currently no treatments, but a drug and vaccine are being tested on animals. This week it was reported that the vaccine appears to reduce symptoms in monkeys, although it is difficult to tell

because the virus only triggers mild symptoms in the animals. "The controls didn't become severely ill, so it isn't possible to say with certainty how the data would translate to humans," says Barney Graham of the US National Institute of Allergy and Infectious Diseases in Bethesda, Maryland (*Nature Communications*, DOI: 10.1038/ncomms8712).

MERS doesn't spread easily between people outside hospitals, so the vaccine would probably be given to healthcare workers, and people working with camels – the suspected source of the virus.

Polio-free Nigeria

AGAINST all odds, Nigeria has had no new polio cases in the past 12 months. The World Health Organization is still checking samples from the last suspected cases, but once it has confirmed them as negative, it can officially take Nigeria off the list of countries where the disease is endemic.

It hasn't been easy. The vaccination drive has been dogged by political corruption, rumours



Going door to door to banish polio

the vaccine was contaminated with HIV, and violence – nine workers were killed by terrorist group Boko Haram in 2013.

The disease continues to spread in Afghanistan and Pakistan, which have reported 5 and 28 cases of polio respectively this year. For each of these, there will be around 199 other people who are infected but symptomless, spreading the virus. “This is an eradication project, and unless we get to zero cases, we’re not going to finish this disease,” says Oliver Rosenbaum of the WHO. “Nigeria will need to keep immunising and protecting the population.”

Clinton greens

THE US will produce enough clean energy within ten years to power every single home there if Hillary Clinton gets elected, the front-running Democratic presidential candidate promised this week.

“The reality of climate change is unforgiving no matter what the deniers say,” said Clinton in Des Moines, Iowa, while unveiling plans to combat climate change by dramatically expanding the use of renewable energy in the US.

The proposals include installing more than half a billion solar panels, raising the renewable proportion of US electricity from 7 to 33 per cent and shifting support away from fossil fuels. “We’ll stop the big giveaways to big oil companies and extend, instead, tax incentives for clean energy,” she said.

Environmental groups broadly welcomed her commitment, but criticised her for ducking questions about whether she supports Keystone XL, the controversial pipeline that would funnel oil from Canada. “This is a strong and thoughtful response to the central environmental challenge of our time, global climate change,” said Ed Chen of the Natural Resources Defense Council, an environmental action group in Washington DC.

Who’s driving?

SMART cars are now hackable. Fiat Chrysler Automobiles has recalled 1.4 million of its vehicles after two hackers showed they could take control of a car via the internet.

In a stunt for Wired, a couple of security researchers took control of a Jeep Cherokee remotely by hacking into the vehicle’s internet-connected entertainment system. After the pair showed that they could change the radio station and the air conditioning, lock the doors and operate the windscreen wipers, they

finally killed the engine and slammed on the brakes. The car ended up in a ditch.

Chrysler drivers will be sent a USB drive containing updates to their car computer’s software that will close the vulnerability.

“After showing they could operate the windscreen wipers and radio, they killed the engine”

The recall comes after two US senators last week announced plans to force car manufacturers to make sure cars are protected from such attacks.

New Horizons sees Pluto’s haze

PLAINS of oozing glaciers and a hydrocarbon haze are the latest surprises to reach us from Pluto.

Seven hours after NASA’s New Horizons spacecraft passed Pluto, it took a picture of the dwarf planet looking back toward the sun (pictured below). Close inspection of the sliver of atmosphere catching the sun showed bands of haze that extend 130 kilometres above the surface, much higher than expected.

The layers of chemical haze are linked to Pluto’s coating of reddish-brown grime: ultraviolet light from the sun breaks down the methane in its atmosphere into hydrocarbons, which produce the haze. These molecules stick together like snow, falling to the surface to give much of

Pluto its rust-coloured dusting.

High resolution images of the surface also revealed more of Pluto’s icy plains, a vast expanse of frozen nitrogen. Not only is this surface free of craters – suggesting it is new in geological terms – but it appears to be flowing around the bases of mountains and filling in the craters at the plain’s borders. “We interpret it to be just like glacial flow on Earth,” says team geologist Bill McKinnon. “To see evidence for recent geological activity is a dream come true.”

Connecting the atmosphere and these glaciers will be key to putting together Pluto’s puzzle pieces. More data will help – though the bulk of that collected in the fly-by won’t reach us until September.

NASA/HULAP/SWRI



Picture perfect

60 SECONDS

Cock-a-doodle-who?

Who decides when it’s time to get up? For chickens, it’s the top-ranking cockerel, who announces the break of dawn based on his biological clock. If he sleeps in, subordinate cockerels will still patiently wait for his call before they start crowing (*Scientific Reports*, doi.org/6gpp).

No to robot weapons

Are we on the brink of an AI war? Artificial intelligence experts, scientists and engineers, including Stephen Hawking and Elon Musk, have signed an open letter calling for a ban on autonomous weapons. “The key question for humanity today is whether to start a global AI arms race or to prevent it from starting,” the letter says.

Stem-cell setback

A pioneering stem-cell trial has been halted after a mutation that could cause cancer was found. The trial, led by Masayo Takahashi at the Riken Center for Developmental Biology in Kobe, Japan, was exploring whether skin cells changed into eye cells could reverse blindness. One patient was treated, but cells from a second patient are now being tested to determine when the mutation arose.

Winds of change in US

Construction of the first commercial-scale offshore wind farm in the US has begun off Rhode Island. The developer, Deepwater Wind, hopes to finish the five-turbine farm in 2016. The US wind-farm industry has been lagging behind Europe’s.

SpaceShipTwo crash

Virgin Galactic’s SpaceShipTwo crashed because co-pilot Michael Alsbury unlocked the spacecraft’s descent system too early, not because of a fault with the craft, a review has found. But the US National Transportation Safety Board also said that Virgin Galactic did not do enough to mitigate the risks, which the Federal Aviation Administration should have spotted.

The fertility calculator

What is the best age to start a family? No one knows for sure, but the decision should be a little bit easier now you can ask a computer

Jessica Hamzelou

IT'S a question many people will ask themselves at some point in their lives: when should I start a family? If you know how many children you'd like, and whether or not you would consider, or could afford, IVF, a computer model can suggest when to start trying for your first child.

Happy with just one? The model recommends you get started by age 32 to have a 90 per cent chance of realising your dream without IVF. A brood of three would mean starting by age 23 to have the same chance of success. Wait until 35 and the odds are 50:50 (see "When to get started", below).

The suggestions are based on averages pulled from a swathe of data so don't give a personal prediction. And of course, things aren't this simple in real life – if only family size and feelings about IVF were the only factors to consider when planning a family. But the idea behind the model is to help people make a decision by condensing all the information out there into an accessible form.

"We have tried to fill a missing link in the decision-making

process," says Dik Habbema at Erasmus University in Rotterdam, the Netherlands, one of the creators of the model. "My son is 35 and many of his friends have a problem deciding when to have children because there are so many things they want to do."

It's a scenario that will be familiar to many; the age at which people have their first child has been creeping up over the last 40 or so years. For example, the average age at which a woman has her first child is 28 in the UK and has reached 30 in Italy, Spain and Switzerland. In the US, the birth rate for women in their 20s has hit a record low, while the figures for those over 35 have increased over the last few decades.

The decision is more pressing for women thanks to their limited supply of eggs, which steadily drop in quantity and quality with age. Female fertility is thought to start declining at 30, with a more significant fall after the age of 35.

Men are thought to have more time. "We do know that there are male age effects, but they don't kick in severely until a man is well into his forties," says Allan Pacey, professor of andrology at the

University of Sheffield in the UK.

The new model incorporates data from studies that assess how fertility naturally declines with age. The team took information on natural fertility from population data collected over 300 years up to the 1970s, which includes data on 58,000 women. While such information has been criticised as being out of date, it represents the best insights into fertility from a population that wasn't regularly using contraceptives, says Habbema.

"We need data from populations in which couples try to have as many children as possible, and these populations are scarce," he says. Figures taken from hundreds of years ago are consistent with those taken more recently, he adds.

Surprising results

The model also includes information on IVF success rates for women of various ages based on 2013 figures from the Netherlands (*Human Reproduction*, doi.org/6ck).

One thing it doesn't account for, however, is the age of the prospective father. While older men are known to be more likely to pass on genetic mutations that increase a child's risk of conditions like schizophrenia, age doesn't seem to strongly affect a couple's fertility until the father is in his late 40s. "Our results are generally valid for couples where the man is not more than 10 years older than the woman," says Habbema. Pacey agrees that this is reasonable, and says that the model is "as good as it can be".

The model is based on averages so won't apply to every woman on



CHRISTOPH EEBERLE/PLAINPICTURE

When to get started

Crunching 300 years' of fertility data, a computer model has come up with the age by which couples should start building a 1, 2 or 3-child family, for a 50, 75 and 90 per cent chance of success. Ages given are for the female partner

Chance of realisation	1-child family	2-child family	3-child family
Without IVF			
50%	41	38	35
75%	37	34	31
90%	32	27	23
With IVF			
50%	42	39	36
75%	39	35	33
90%	35	31	28

an individual basis as there is a lot of variation, but it could be very helpful, says David Keefe at New York University Langone Medical Center. "It makes explicit certain statistics that don't sink in for many people," he says.

Some of the results may come as a surprise. For example, pregnancy remains an option for

"If you are relaxed about having 3 kids you can wait until 35, but you've got to start early to be certain"

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Want one... or three?

women in their early 40s – with the chance of conceiving about 50 per cent. At the other end of the spectrum, the early age at which the model suggests you should start having children if you want a 90 per cent chance of having three – 23 – may be a shock to a generation who are waiting until their late twenties and early thirties to even consider the prospect.

On reflection, however, the figure makes sense, says Pacey. “You’ve got to factor in that

people don’t necessarily have children in quick succession,” he says. “What it is saying is that if you’re relaxed about having three children, you can wait until you’re 35, but you’ve got to start early to be certain.”

“In general, young people are very optimistic about their reproductive potential,” says Ulla Waldenström at the Karolinska Institute in Stockholm, Sweden. “They also have a lot of faith in reproduction technologies – there is a strong belief that if

you can’t get pregnant naturally, there is always IVF, although it is far from a guarantee.”

According to the model, IVF only increases the upper age for starting a family of any size by a few years. “IVF has limited impact, and that might surprise people,” says Habbema.

Habbema admits that other factors will influence decisions made by potential parents, such as their career and relationship stability, and the available childcare resources. “It’s not easy to make recommendations,” he says. “I hope the model will play a part in making decisions easier.”

Women in their 30s who want to have children needn’t worry yet, says Keefe. “Some might

“There is a strong belief that if you can’t get pregnant naturally, there is IVF – but it’s no guarantee”

think: ‘oh my gosh, I have to get started’, but for many women that’s not true,” he says. “For women at the age margins, this could help nudge them one way or another, but we don’t want to force people to change their lives.”

Pacey thinks the table should be widely circulated. “The table ought to be photocopied and put up on the clinic wall,” he says. “We should also be aiming this at sixth formers [college students] and university students, so that they’re aware of how to plan their life.” The best way to inform both young men and women, without pressuring or scaring them, might be to integrate fertility awareness into lessons on contraception that are routinely delivered at schools.

Such education programmes are being launched in Sweden, says Waldenström, and the British Fertility Society is planning to run a similar scheme in the UK.

“We haven’t got a time machine we can put people in... that’s just a blunt reality,” says Pacey. “Everyone thinks they can wait – this shows that you can’t.” ■

EXPERT’S VIEW

We need to get the message right

Adam Balen, chair of the British Fertility Society

The information captured in the fertility model is extremely important to have out there. There’s been a lot of publicity recently about the decline in fertility with age – not all of it well informed. This is such an emotionally charged subject with such fundamental consequences, we need to get the message right.

In June, for example, one scientist suggested that women who haven’t started a family by the age of 35 should freeze their eggs. But this doesn’t guarantee a family – eggs don’t always freeze well, and you need to freeze quite a few to give yourself reliable insurance.

It’s also been suggested that all men should have their sperm frozen at the age of 18. That’s even more ludicrous, because while male fertility falls with age, the effects don’t kick in until the late forties.

Young people today expect to have complete control over their life. The messages about unwanted pregnancy are clear – you can control that with contraception. But when it comes to getting pregnant things are less clear. For most people, it’s not as simple as coming off the pill.

It is our duty to educate people about the decline in fertility with age. There is also a case for providing fertility checks to couples. At the moment, such tests aren’t widely available to healthy people, but I don’t see why they shouldn’t be.

Couples need support so they can start their families early. Women who have children in their 20s are more likely to achieve their desired family size but can also expect lower lifetime earnings than women who start later. We need to ensure women aren’t disadvantaged at work, and sort the lack of childcare facilities so we can enable young couples to establish their careers and families at the same time.

As told to Jessica Hamzelou

Earth now halfway to warming limit

Michael Le Page

IT'S the outcome the world wants to avoid, but we are already halfway there. All but one of the main trackers of global surface temperature are now passing more than 1°C of warming relative to the second half of the 19th century, according to an exclusive analysis done for *New Scientist*.

We could also be seeing the end

"The slowdown in warming since 1998 was partly due to oceans taking up more heat. That could be over"

of the much-discussed slowdown in surface warming since 1998, meaning this is just the start of a period of rapid warming. "There's a good chance the hiatus is over," says Kevin Trenberth of the National Center for Atmospheric Research in Boulder, Colorado.

Last year was the hottest since records began, but only just. With an El Niño now under way – meaning warm surface waters in the Pacific are releasing heat into the atmosphere – and predicted to

intensify, it looks as if the global average surface temperature could jump by around 0.1°C in just one year. "2015 is shaping up to smash the old record," says Trenberth.

The UN negotiations on climate change aim to limit warming to 2°C above pre-industrial temperatures. There is, however, no agreement on how to define pre-industrial temperature, says Ed Hawkins of the University of Reading, UK.

Because some global temperature records only begin in 1880, the period 1880 to 1899 is the easiest "pre-industrial" baseline for measuring warming. It is somewhat misleading, though, because the 1880s were particularly cold after the eruption of the Krakatoa volcano. The period 1850 to 1899 is a better baseline, says Hawkins.

What's more, there are several long-term records of global annual average surface temperatures. All differ slightly because they use slightly different data sets and have their own ways of adjusting for relocations

of weather stations and changes in instrumentation over time.

Kevin Cowtan of the University of York, UK, created and still maintains one such record, called "Cowtan & Way version 2.0". It is based on another record, maintained by the UK Met Office, called HadCRUT4. Cowtan's version differs because it compensates for missing data from areas with few weather stations, like the Arctic.

The various records also show

temperature changes relative to different baselines. For instance, NASA's GISTEMP record shows warming relative to the 1951 to 1980 average.

At the request of *New Scientist*, Cowtan adjusted his and other measures to show annual warming relative to the same time frame: the 1850 to 1899 period. All but one set of adjusted figures show that we will have already passed 1°C before the next round of UN talks on a global climate treaty get under way in December (see graph, left).

"It looks very likely that all except HadCRUT4 will break 1°C this year," says Cowtan. "HadCRUT4 is somewhat dependent on a strong El Niño boost."

And if climate talks do not lead to drastic action, we could pass the 2°C mark around the middle of the century. The planet may continue to warm fast in the coming years, at a rate more like those from 1984 to 1998, when it warmed at 0.26°C per decade.

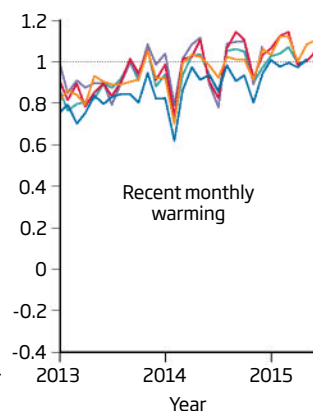
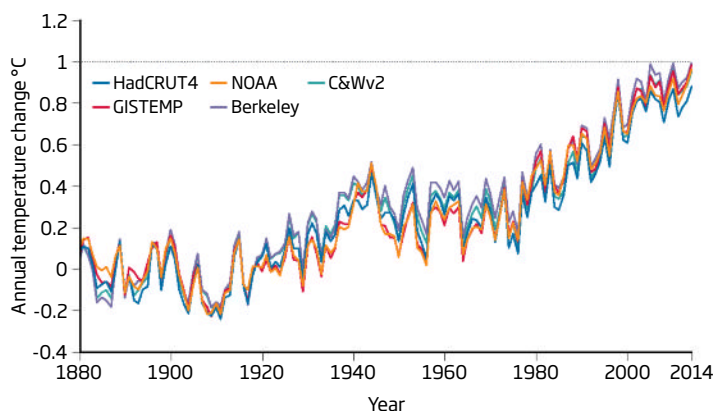
From 1998 to 2012, the rate slowed to about 0.04°C per decade, according to the last International Panel on Climate



MOHAMMED SALEH/REUTERS

Halfway to hell

This year, all except one of the main indicators of global average surface temperature looks set to show a 1°C rise over the pre-industrial baseline



SOURCE: KEVIN COWTAN, YORK UNIVERSITY

Insight Sea-level rise

Superstorms possible even with 'safe' 2°C rise

HIGHLY speculative. Full of conjecture. Based on flimsy evidence. Not supported by mainstream science. Not peer reviewed.

It sounds like climate scientists are talking about the claims of climate deniers. But this time they are talking about a 23 July discussion paper by James Hansen, one of the most respected climate scientists.

Hansen starts by arguing that the ice melting on and around Greenland and Antarctica will cause rises in sea level that are much faster than mainstream predictions, meaning that we are likely to see several metres of sea-level rise this century. It is an argument that he has been making for a long time: for instance, in his 2007 feature for *New Scientist*.

Even more startling are the consequences that Hansen thinks will result from this rapid melt. Because fresh water is less dense than saltwater, the cold, fresh meltwater will pool around the coasts of Greenland and Antarctica.

Around Antarctica, this surface layer will act as a blanket, floating on top of warmer, saltier water and preventing it from losing heat to the air. Instead, this heat will go into

unlike anything we have ever seen.

Most terrifying of all, Hansen thinks that all of this could happen with just a 2 °C rise in temperature – the supposedly safe limit.

The consequences, of course, would be catastrophic. "It is not difficult to imagine that conflicts arising from forced migrations and economic collapse might make the planet ungovernable, threatening the fabric of civilisation," the paper states.

These claims do not reflect the views of most climate scientists. But here is the take-home message: we cannot be sure that Hansen is wrong.

When it comes to sea level, most glaciologists now agree that we are heading for sea-level rises of at least 5 metres. There is also wide agreement that large-scale melting of Greenland's ice will shut down ocean circulation. The only contentious issue is how fast these things will happen.

There is certainly no agreement about the superstorms that Hansen predicts. But his argument is based on simple physics: winter storms are driven by the temperature difference between the poles and tropics, so if this difference temporarily increases, stronger storms will follow.

The fact is that many of the consequences of rising greenhouse gases are extremely difficult to predict. We can be pretty confident about how much the planet will warm and how much the sea level will rise because there is plenty of evidence from the past, but beyond this there are huge gaps in our knowledge.

The "official" projections of climate scientists have turned out to be too conservative time and time again. Antarctic melting is already a century ahead of schedule, for example. Hansen, by contrast, has a history of making predictions that turn out to be bang on the money.

That does not mean he is right again. But the mere possibility that he might be should make us all pause for thought. **Michael Le Page** ■

2015 is shaping up to be a scorcher

Change report. This was due to a combination of factors: a less active sun, higher levels of cooling aerosols from volcanoes and Asian factories, and increased heat uptake by the oceans.

One reason the oceans took up more heat was because of a phenomenon known as the Pacific Decadal Oscillation. The surface of the northern Pacific tends to flip between being extra cold and extra hot every two or three decades. It was in a cold, negative phase but now appears to have switched to a positive one, Trenberth says.

So temperatures might briefly drop next year after the current El Niño ends, he says, but the average warming rate over the next decade or so could be closer to the 0.2 °C per decade predicted for the business-as-usual pathway we are on.

We are also on the cusp of another ominous milestone: the level of carbon dioxide in the atmosphere is starting to edge past 400 parts per million. And with global emissions of greenhouse gases rising ever faster, there's no end in sight to the grim trend. ■

"It is not difficult to imagine that conflicts from forced migrations might make the planet ungovernable"

melting the underside of ice shelves and glaciers. Hansen argues that the growth in sea ice around Antarctica is a sign that this is starting to happen already, with freshening surface water forming sea ice more readily.

This freshwater layer will also shut down the currents that carry heat from the tropics to the poles, he argues, so the tropics will warm fast while high latitudes cool down because of the cold surface waters. This temperature difference, Hansen claims, will power superstorms



Calm before the storm?



Not time to wake up

A conscious brain is a little unstable

Jessica Hamzelou

IT'S the day of your operation. As the anaesthetic kicks in, you start to drift off... only to reawaken with a scalpel cutting away at you. It is the stuff of nightmares, and there is no fail-safe way to stop it happening, says anaesthesiologist Alex Proekt, at Weill Cornell Medical College in New York.

People wake under general anaesthetic about once in every 19,000 cases, according to a large study last year, and when paralysing drugs have been used, their awake state can go unnoticed. But that might be about to change. There is mounting evidence that the stability of brain activity could indicate when a person is no longer still under, and enable us to do something about it.

Proekt and his team used grids of electrodes placed directly on the brain to record the activity of four monkeys as they lost consciousness under one of two common anaesthetics. They then

used computer modelling based on dynamical systems theory to test how stable this activity was.

According to this theory, stable systems can respond to changes by returning to a baseline state, whereas unstable systems go haywire. While awake, the monkey brains seem poised between mathematical stability and instability. But as the monkeys succumbed to anaesthesia, the activity of their brains became more stable

"The human brain performs a delicate dance between stability and instability"

(*Journal of Neuroscience*, DOI: 10.1523/jneurosci.4895-14.2015).

A study in April found that tiny bursts of stability, in which brain activity holds steady for hundreds of milliseconds, are necessary for us to consciously perceive something. But Proekt's work suggests that if this goes on for too long, you will become

unconscious. Conversely, modelling suggests that if signals spread too much, this may also cause a loss of consciousness. "The brain is somehow balancing between the two," says Proekt.

Together, the studies illustrate the delicate balance of the conscious brain, says Aaron Schurger of the Swiss Federal Institute of Technology in Lausanne, who did the earlier work. "The system is pushed towards the boundary between stability and instability so that it can perform a delicate dance from one state to another," he says.

Doctors can currently use methods like EEG monitoring of brain activity to check whether a patient is still unconscious. But the signals that these monitors pick up vary with the depth of anaesthesia, and don't work for certain drugs. By EEG measures, the brain of someone knocked out with ketamine looks the same as that of an awake person.

Proekt thinks being able to record and test the stability of brain activity in real time will allow him, and other anaesthetists, to more accurately assess the consciousness of the people they are putting to sleep and keep them under for the required length of time. ■

Neptune's jump left a weird ring of icy bodies

BILLIONS of years ago, Neptune made one giant leap. This jump left behind a close-knit group of icy objects called the Kuiper belt kernel, 6.5 billion kilometres from the sun, according to a new study.

The Kuiper belt is a collection of icy planetesimals that sits beyond Neptune. Astronomers estimate that it has trillions of members, including dwarf planets like Pluto - remnants of the solar system's formation more than 4 billion years ago that have hardly changed since.

Most of the Kuiper belt's population is scattered far above and below the neat plane in which the planets lie. Members of the kernel, however, stick tightly to that plane and to each other. No one knew why, until David Nesvorný of the Southwest Research Institute in Boulder, Colorado, made a simulation of them.

His simulation rewinds the solar system's history, showing the kernel's formative years (arxiv.org/abs/1506.06019). The kernel started life in Neptune's gravitational clutches, but further from the sun. The planet slowly wandered outwards, and pushed these icy objects with it.

But, when it was 4.2 billion kilometres from our star, Neptune shifted its orbit suddenly, probably because of a close encounter with another planet. The kernel couldn't keep up: the objects escaped Neptune and remained together, exactly where they were at the time.

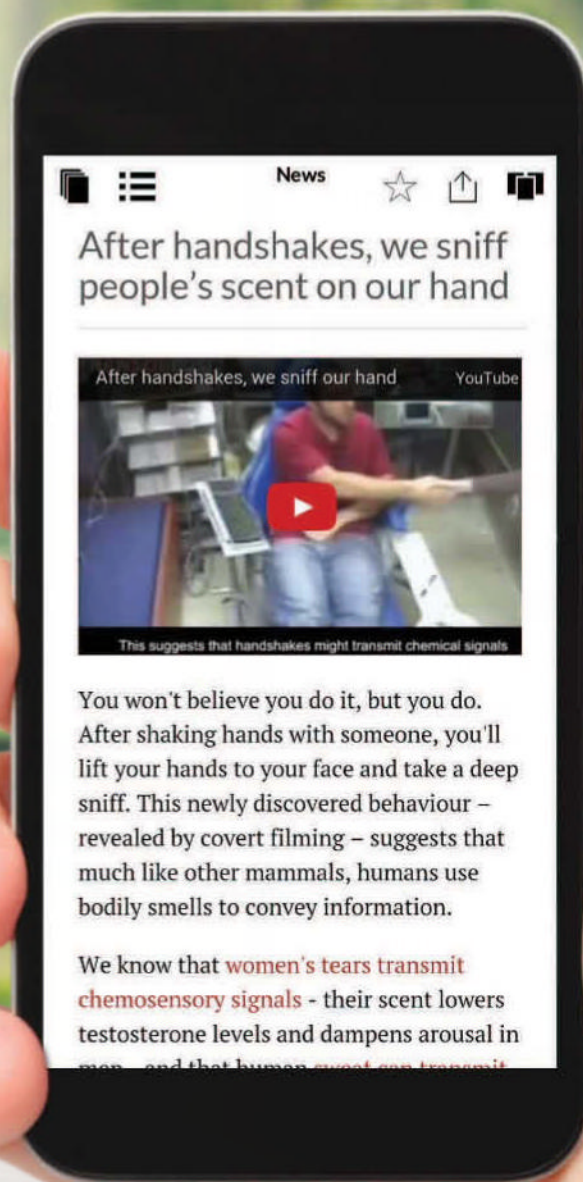
Learning more about the Kuiper belt's composition and how it is distributed can help us understand the solar system's babyhood and how it matured. NASA's New Horizons mission, which flew past Pluto last month and beamed us the first-ever close-up pictures of the dwarf planet, will help pin down these details.

"The Kuiper belt is a perfect clue to understanding how the solar system evolved since its formation," says Nesvorný. Sarah Scoles ■

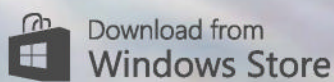
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Giant fauna killed by heat, not humans

Michael Slezak

HUMANS were not to blame for the extinction of prehistoric giant mammals after all – global warming was the real culprit, according to new evidence.

Ever since a giant sloth was uncovered more than 200 years ago, hinting at the existence of an ancient menagerie of megafauna, our ancestors have been on trial for their extinction.

“The overwhelming evidence is that the megafauna extinctions occur around the world whenever humans turn up,” says Alan Cooper, who researches ancient DNA at the University of Adelaide in Australia. But that’s not the whole story. Look closer and the pattern emerging is that climate change is linked to extinctions, regardless of whether humans were there or not, he says.

Cooper’s team has produced a timeline of changes in megafauna populations around Eurasia and North America over the last 56,000 years, and matched it up with ancient climate records.

The timeline punches a hole in one of the prosecution’s key arguments, that climate change

cannot have driven animals to extinction because they survived lots of warm and cool periods in the past, only to die apparently when humans arrived on the scene. According to Cooper’s evidence, that argument doesn’t wash. Megafauna extinctions were relatively common whether humans were around or not.

Two strands of evidence allowed the team to figure this out. First, they compiled 10 years of work on ancient DNA that had

uncovered a series of “invisible” extinctions. These are events involving two or more lineages with identical skeletons but different genomes – two species of bison, say. That means if both species lived in the same area, we could not tell just from the bones that a species had gone extinct.

Secondly, they created a new ancient climate record spanning the same time period that could be reliably linked with the carbon dates from bones to show when particular extinctions happened. Usually, timelines for climate change and carbon dating are independent and difficult to link. But Cooper’s team found a marine sediment that contains a record of both past climates and

microfossils, allowing them to link climate and carbon dating.

They found that periods of warming – rather than cooling as some suggested – were linked to extinctions (*Science*, doi.org/6gb). “Climate is the thing that is constantly sending these species out through time without humans even being involved,” says Cooper.

But he is not letting humans off entirely. There was an uptick in extinctions at the end of the last ice age when, famously, the woolly mammoth met its maker.

While humans probably did not hunt species to extinction, farming would have disrupted landscapes and prevented species fleeing to escape the effects of climate change.

Cooper’s findings also provide a stark warning for the future, according to Brian Huntley from Durham University, UK. “Human alteration or destruction of ecosystems is so pervasive that it is clear that many species are unable to shift their ranges sufficiently rapidly to match current anthropogenic climatic changes,” he says.

It’s not yet clear if the same pattern will hold elsewhere. For example, in New Zealand and Australia, extinctions correlate with human arrival, rather than warming, says palaeontologist Tim Flannery from Sydney, Australia. ■



REMKO DE WAAL/EPA

Flight not an option for mammoths

Map galactic life to test whether it likes to travel

DOES life spread like an interstellar infection? If we spot it on clusters of planets, that might suggest it doesn’t stay put wherever it evolves.

The theory that life crosses space to reach new worlds, called panspermia, is hard to test. Life on Earth could have been seeded by just one microbe-laden rock, but there are too many rocks to check, even if we had a

foolproof test for extraterrestrial life. “That’s not a very effective strategy of testing whether life came from outer space,” says Henry Lin of Harvard University. He says the answer lies in mapping life across the galaxy.

Future probes like NASA’S James Webb Space Telescope will scrutinise the atmospheres of planets in other solar systems for possible signs of biological activity. If life spreads between planets, inhabited worlds should clump in space like colonies of bacteria on a Petri dish. Otherwise, Lin says, its signature would be seen on just a few, randomly scattered planets.

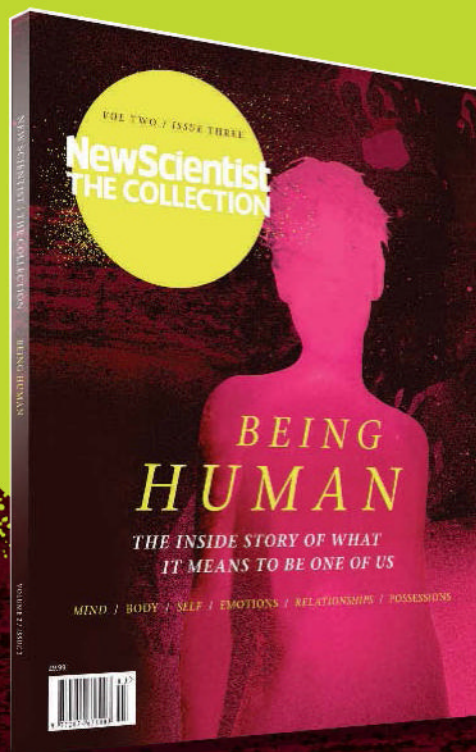
Lin argues that if we find 25 worlds with life on one side of the sky and 25 lifeless ones on the other, it might mean the sun sits on the edge of a panspermia bubble – a strong sign that life radiated outward. “We would have smoking-gun evidence that panspermia actually happens,” he says (arxiv.org/abs/1507.05614).

But panspermia would be harder to confirm from the bubble’s centre.

“If life spreads between planets, inhabited worlds should clump in space like bacteria on a Petri dish”

If there are biosignatures all around as far as we can see, for example, we can’t draw conclusions one way or the other. And if we see only scattered life, Lin says, that could suggest either that panspermia doesn’t happen or that it proceeds so slowly as to be rare.

Sara Seager of the Massachusetts Institute of Technology doubts Lin’s scenarios will come in handy any time soon. “It would be great if there’s a time in which we have so many biosignatures that we see clumps throughout the galaxy. But I don’t know when that time will be,” she says. Joshua Sokol ■

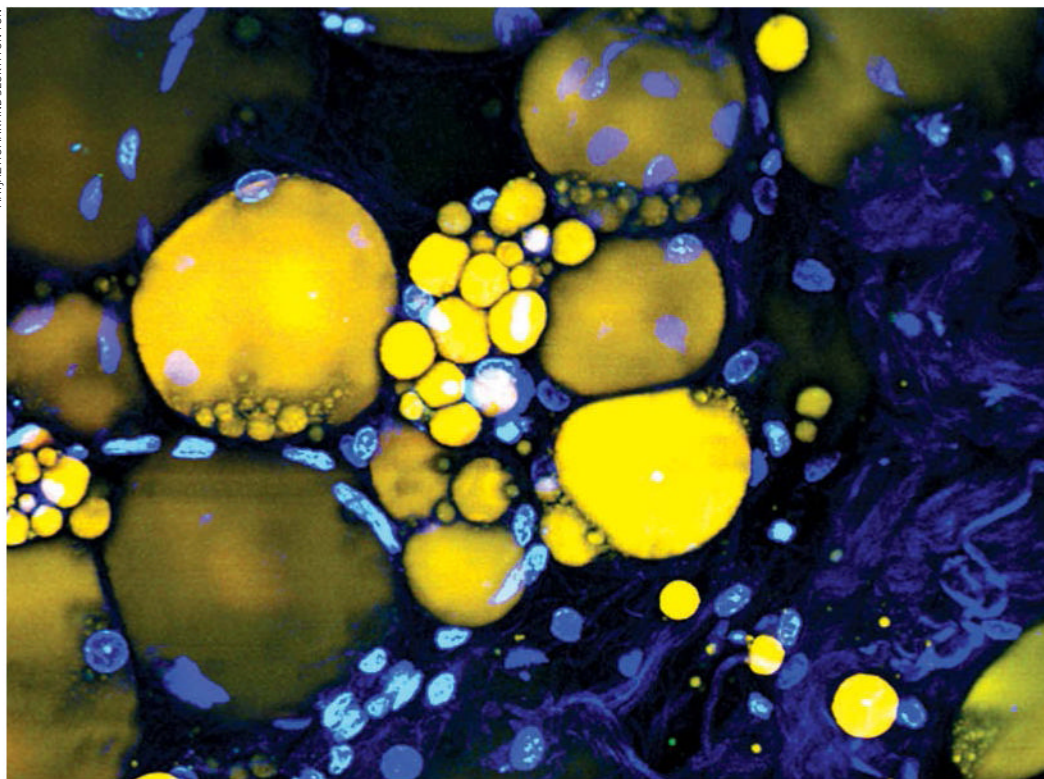


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Droplets of oil turn human cells into living lasers

INDIVIDUAL cells have been made to act like tiny lasers, allowing them to be monitored more accurately.

Making cells shoot laser beams may sound fantastical, says Matjaž Humar of Harvard Medical School in Cambridge, Massachusetts, but the techniques are surprisingly straightforward. "It's actually super-easy."

Humar and his colleagues developed three ways to get cells to emit visible light. The first involved injecting each one with a tiny oil droplet – this formed an optical cavity in the cell that could be filled with fluorescent dye. When a light pulse was shone onto the cavity, the dye atoms

entered an excited state, emitting light.

In a less invasive procedure, polystyrene beads were scattered in a Petri dish filled with macrophages, a type of white blood cell that ingests foreign material – such as the beads. Once ingested, the 10-micrometre-wide beads performed the same function as the oil droplets, acting as an optical cavity capable of emitting highly focused laser light.

The final mechanism involved exploiting the fatty droplets already found within living cells (the yellow spheres above). "We all have these fat cells inside our tissue. We are all made of lasers," says Humar (*Nature Photonics*, DOI: 10.1038/nphoton.2015.129).

The technology could be used to monitor the spread of tumour cells or the behaviour of immune cells.

Earth's magnetic pole may not flip soon

FLIPPING heck! Deposits from fires set by farmers centuries ago reveal that Earth's magnetic field dramatically weakened in the past without actually flipping – suggesting that current field weakening might not necessarily lead to a pole swap either.

Earth's poles have swapped in the past, but without a regular pattern, says Rory Cottrell of the University of Rochester in New

York. This means we don't know when they will flip again – but many suspect it might be soon: the field has been weakening since about 1840. A flip may affect our power grids and communications systems.

Cottrell's team examined magnetic minerals that had their magnetism orientated when South Africa's farmers lit fires between 500 and 1000 years ago.

This captures the size and direction of Earth's magnetic field. "It fixes the magnetic field at that time," says Cottrell.

The analysis shows that around the year 1370, field strength was falling by 0.054 microteslas a year – substantially faster than today's drop of 0.036 microteslas (*Nature Communications*, DOI: 10.1038/ncomms8865).

Until now, we'd had a poor record of magnetic field changes in the southern hemisphere.

Autistic kids can read body language

THE eyes may be windows to the mind, but for children with autism, the body is the better communicator. They are just as good at reading emotions in body language as those without autism.

The finding challenges the idea that children with autism have difficulty reading emotions. This may have arisen from studies focusing on whether children can read emotions from just the face or eyes, says Candida Peterson at the University of Queensland in Australia. "Autistic people don't like making eye contact," she says, as this requires a close encounter with someone. Reading body language can be done from afar.

In the study, children aged 5 to 12 were shown photos of adults with blurred faces posing in ways to convey six emotions. Those with autism were just as good as those without at recognising the emotions (*Journal of Experimental Child Psychology*, doi.org/6dp).

Drug resistance builds better bugs

RESISTANCE doesn't just allow bacteria to evade drugs – it also makes them stronger. The finding challenges the dogma that drug resistance comes at a cost to the bacterium.

David Skurnik at Harvard Medical School in Boston exposed healthy mice to various strains of bacteria, some with antibiotic resistance. These were better at surviving than the non-resistant ones (*Science Translational Medicine*, doi.org/6ds).

Most efforts to tackle resistance have focused on minimising the use of antibiotics, the idea being that this would give non-resistant bacteria the chance to outcompete their supposedly weaker counterparts. Skurnik's work suggests it won't be this easy.

Why was the Black Death so deadly?

THE secret of plague's death toll is out. The high mortality rate seen during the Black Death in the 14th century may have been caused by poor general health rather than by the strength of the bacteria.

The Black Death killed about 60 per cent of Europe's population. That's surprising as recent plague outbreaks weren't as devastating.

"There is a huge difference in mortality rates," says Sharon DeWitte at the University of South Carolina, even though 14th century and 20th century plagues were caused by the same bacterium, *Yersinia pestis*, and its genetics were similar in both outbreaks.

DeWitte believes that the high mortality rate in the 14th century may have been the result of a general decline in health. She examined skeletons in London cemeteries from the 11th, 12th and 13th centuries and found that more adults under the age of 35 were buried in the 13th century.

This suggests that people were dying younger before the Black Death arrived – probably because of famine and an increase in disease burden from other pathogens (*American Journal of Physical Anthropology*, doi.org/6dt).

"Together with historical data, the picture that emerges is that the population was not doing well," says DeWitte.



What would happen if a massive comet hit the sun?

MOST comets that brush past the sun end their lives in a whimper. But a big enough comet plunging into our star should go out with a massive bang.

Three or more comets pass very close to the sun every week. The smaller ones of these "sungrazers" usually melt in the intense glare of solar radiation. But recently we've seen comets make it closer to the sun's surface than we ever have before. In 2011, comet Lovejoy actually passed through the solar corona, emerging much worse for wear but still loosely together.

So what would happen if a comet hit the sun head on? A team led by John Brown, Astronomer Royal for Scotland, calculated the answer for what he calls "supersonic snowballs in hell".

To reach the sun's lower atmosphere, a comet would need a mass of at least 10^9 kilograms – roughly 100 times smaller than comet Lovejoy. If a comet was big enough and passed closer than Lovejoy did, the steep fall into the sun's gravity would accelerate it to more than 600 kilometres a second. At that speed, drag from

the sun's lower atmosphere would flatten the comet into a pancake right before it exploded in an airburst, releasing ultraviolet radiation and X-rays that we could detect from Earth (*The Astrophysical Journal*, doi.org/6dq).

The crash would unleash as much energy as a magnetic flare or coronal mass ejection, but over a much smaller area. "It's like a bomb being released in the sun's atmosphere," Brown says. A true impact like this is likely to only happen once a century at most.

Icy balls fall faster than steel in water

SKATERS know how slippery melting ice can be. It turns out that ice also reduces friction under water.

Ivan Vakarelski of the King Abdullah University of Science and Technology in Thuwal, Saudi Arabia, and his team made ice-coated tungsten carbide balls to match the size and weight of solid steel balls. They then dropped both kinds into a tank of water to see which fell fastest. "If you think about the physics, it's not obvious what the answer is," says Derek Chan of the University of Melbourne, Australia.

The icy balls fell faster and had far less drag. High-speed video showed that when the balls first entered the tank, a turbulent wake formed behind them, slowing them down. But as they fell, their wakes narrowed, streamlining their path through the water. Icy balls dropped in 22°C water reached that point much faster but did not get a speed boost in 6°C water, where they melted less (*Physical Review Letters*, doi.org/6gg). This suggests that melting ice is key – it may transfer momentum away from the ball's surface. The discovery could help with studying icebergs, says Chan.



JULIUS T. COSTON

The first snake fossil with four legs

SOME 120 million years ago, dinosaurs still ruled the world – and some snakes had four legs. One of them was *Tetrapodophis amplexus*.

A range of features show that this unusual creature was indeed a snake, says David Martill of the University of Portsmouth, UK, whose team described the fossil found in Brazil. It has a single row of belly scales, hundreds of snake-like vertebrae, a body longer than the tail and backward pointing teeth.

Primitive snake fossils with hind legs have been found before, but never one with all four legs of its

lizard ancestors. "They are very, very small, and did not perform as walking legs," says Martill. Instead, his team thinks they were used to grasp prey or mating partners.

The fossil adds weight to the idea that snakes evolved from burrowing lizards and not from marine lizards (*Science*, doi.org/6dv). "[It] doesn't show any aquatic adaptations – no long, oar-like tail, no flippers," says Nicholas Longrich of the University of Bath, UK. "But it does show some pretty classic burrowing features, like low spines on the vertebrae, and a short tail and a long trunk."



Mixing business and pleasure

Holiday returns

Having a break isn't just about relaxing, finds **Aviva Rutkin**. It could also be a way of making a bit of extra spending money

GETTING away from it all can be a chance to rake it in. A crop of start-ups is looking to change the way people travel by encouraging them to rent out their stuff – their car, their spare luggage space, even their skills – to those who need it.

Take Flyta, a “social shipping” company in Ottawa, Canada, that launched in April. Holidaymakers can post their travel dates and destinations, connect with strangers looking to ship something to the same spot and offer to take it for a fee.

When the company first started, CEO Farhad Khan used it to shuttle mobile phones and laptops between the offices of a software company. Now, users rely on it to receive things that are rare or expensive in their home country, such as textbooks, regional brands of food or even medical devices. The method is much cheaper

than traditional shipping, says Khan. “It saves a lot of hassle.”

Carhood in Melbourne, Australia, also aims to help travellers cut costs. Rather than leave their car in the airport car park, travellers flying from Melbourne can drop it off with Carhood. While they're gone, the company will clean and store the car for free in exchange for the right to rent it out. Since its launch earlier this year, more

than 1000 people have offered up their vehicles.

“How much stuff do you have that you don't use?” says Christian Schaefer, co-founder of Carhood. “The power of today's economy is in ourselves and the way in which we're learning to share things with others.”

This idea powers the “sharing” or “gig” economy: the range of online services that let people connect directly with each other

THE GIG ECONOMY

The sharing economy has spawned a wide range of apps and services.

MONEY: TransferWise in London enables users to exchange currency by connecting them with someone looking to transfer an equivalent amount in the opposite direction.

FOOD: With Instacart, a start-up based in San Francisco, those who are too busy to shop can find

someone to pick up and deliver whatever they need.

RIDES: The apps Uber and Lyft let users turn their cars into taxis. For those with a little more cash to spare, New York City-based Blade offers on-demand helicopter rides.

ANYTHING ELSE: TaskRabbit lets users book someone to do odd jobs for an hourly rate.

thanks to modern technology. On a laptop or a smartphone you can quickly find someone with the right skills or in the right place, establish a basic level of trust via messaging or video chat, and then beam payment to them when all is done.

On GoCambio, a website based in Cork, Ireland, that launched in March, travellers looking for a place to stay can offer language lessons instead of money. In the future, the company hopes to expand this to include other skills, such as tutoring or playing guitar.

“Everyone has something they can share with someone else,” says Rosie Mansfield, managing director of GoCambio.

The undisputed sharing king in the travel industry is Airbnb, which enables people to rent out their flat, bedroom – or even tree house. Since its launch in 2008, the company has become wildly popular, with more than a million listings worldwide. Its success has inspired websites such as PlateCulture, which lets users turn their homes into restaurants, and Rover, which offers peer-to-peer pet sitting.

But relying on strangers rather than professionals carries added risk that the companies must find

“On GoCambio, travellers looking for a place to stay can offer language lessons instead of money”

a way to mitigate. Flyta, for example, asks users to pass a background check and agree to a temporary hold of money on their credit card before carrying packages.

Companies such as these are dramatically changing how people experience new places, says Pauline Frommer, who is editorial director of the travel guidebook series Frommer's and encourages people to try social housing sites.

“You're more likely to meet and have conversations with people,” she says. “I think it's a wonderful development.” ■

INSIGHT Online security

Can data ever be deleted?

The traces we leave online can return to haunt us, says **Sally Adee**

THEY thought they could get away with it. The 37 million users of adultery social network Ashley Madison (which has the slogan "Life is short. Have an affair") had a get-out clause.

Ashley Madison, like some other sites, offers a hard delete – a guarantee that for a certain amount of money, your data will be scrubbed from all of its internal records. To permanently destroy all traces of your affiliation costs £15 in the UK.

Now a hacker collective called Impact Team has revealed that some customer details remain. Compliance with auditing requirements means that the credit card details and name used to erase the account remain in Ashley Madison's database, the collective says, rather defeating the point.

Serves them right, some might say. But the Ashley Madison hack is a reminder that there is a big gap

between what firms tell us they do with our data and what they actually do. There is a lot of wiggle room in the technical details.

Take Facebook, for example. The site advises that when you delete your account, people won't be able to see it on Facebook. However, just

"Copies of some material may remain in our database for technical reasons"

because you can remove your profile from its servers doesn't mean no data about you remains with Facebook.

"Facebook's data policy is ambiguous on what exactly it promises to delete after you delete your account," says Brendan Van Alsenoy, a legal researcher at the Catholic University of Leuven (KUL) in Belgium. So while

Facebook is legally bound to delete things like status updates, the same legal protections may not apply to information that isn't public-facing.

"Copies of some material may remain in our database for technical reasons," a Facebook representative told *New Scientist*. "When you delete your account, this material is disassociated from any personal identifiers." According to European Union law, you can't insist on deletion if the data has been sufficiently anonymised, says Van Alsenoy.

Google's fine print reveals similar caveats. While the company lets you delete your search history, it keeps the search logs, but dissociates them from your Google account, making them anonymised.

However, data anonymisation is becoming increasingly unrealistic. "Re-identifying supposedly anonymised data has been demonstrated many times," says information privacy legal scholar Paul Bernal of the University of East Anglia, UK, and it will only get easier as re-identification techniques become more sophisticated.

Things might be improving. EU regulators have issued new guidelines on anonymisation, and the proposed reform of EU data protection includes an explicit "right to erasure".

So how would such information come to light? A hack would do it. But even if every company kept your information far from a hackable internet connection, there are still other ways for it to reappear.

Many companies have fallen to the fickle winds of Silicon Valley. If Facebook crumbles, its valuable data may be sold on.

For the time being, no one knows what data is kept, how identifiable it is, or how it can be strung together eventually – even if you have paid to delete that incriminating profile. ■

ONE PER CENT



Fair game

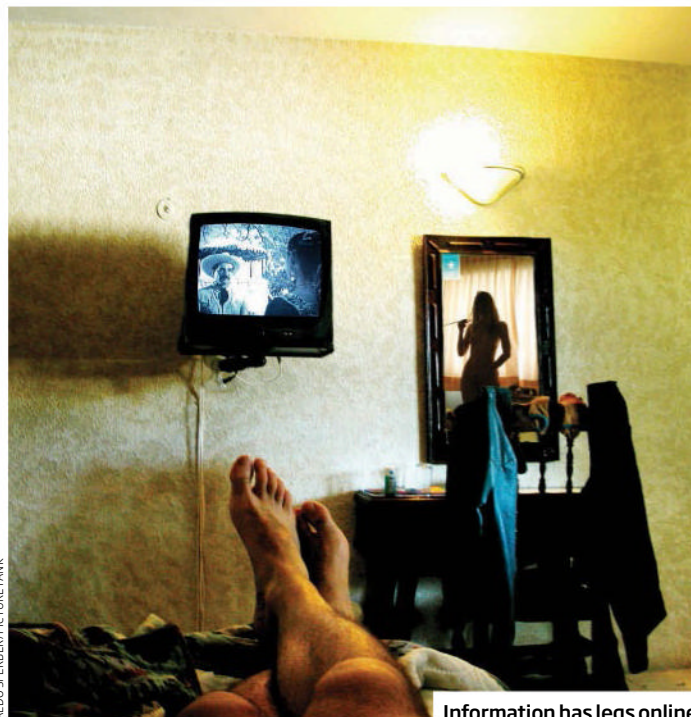
Esports is saying no to drugs. The Electronic Sports League announced last week that it will start testing professional video gamers for doping. The move comes after player Kory Friesen, aka "Semphis", admitted in an interview that his team took Adderall during a recent tournament. The screening will start at the ESL One tournament later this month in Cologne, Germany.

"Just because you have access to an expensive toy that can fly in a dangerous area doesn't mean you should do it"

Assemblyman Mike Gatto of Glendale, California, in a statement introducing laws that will let firefighters disable drones that are interfering with their work, following a number of incidents in the state

Mirror, mirror

Your mirror might soon let you reflect on your health. WizeMirror, an EU-funded project, will fit mirrors with multispectral cameras and a 3D scanner that analyse a person's face and blood flow to work out if they are at risk of heart disease, for example.



Information has legs online

ALDO SPERBER/PICTURETANK

MARCUS YAM/POLARIS/EYEVINE



See binary stars from your desktop

Gaming without the game

Exploring new worlds is the point for some, finds **Douglas Heaven**

IT TOOK Kimmo Proudfoot days to save up for an Asp Explorer. With a hyperspace jump of 35 light years, the Asp can cover vast distances in a few hops. Even so, not many attempt the 1200-light-year trip to the Orion Nebula.

"It was a long and arduous voyage, but I eventually made it," says Proudfoot. "As I toured the area I was filled with awe at how beautiful it was. It's a bit like the feeling you get watching a good sunset, but orders of magnitude more mesmerising."

With 400 billion stars to discover, exploration is a popular pastime in *Elite: Dangerous*, which was made by Frontier, a studio based in Cambridge, UK. The game sets players loose in a 1:1 simulation of our galaxy that is generated by algorithms fed with real data. Many players busy themselves with trade, piracy or bounty-hunting. But the intrepid ones spend their time exploring.

Proudfoot moderates an online forum dedicated to exploration in the game. It lets players share images and videos of beautiful or unusual things they encounter.

Elite is one of several games

with a computer-generated playground so vast that players will never come close to seeing all of it. *No Man's Sky*, a space-simulation game due out next year, is set in an algorithmically generated galaxy with so many planets that – so its makers claim – visiting them all would take longer than our sun's lifetime, even at the rate of one a second.

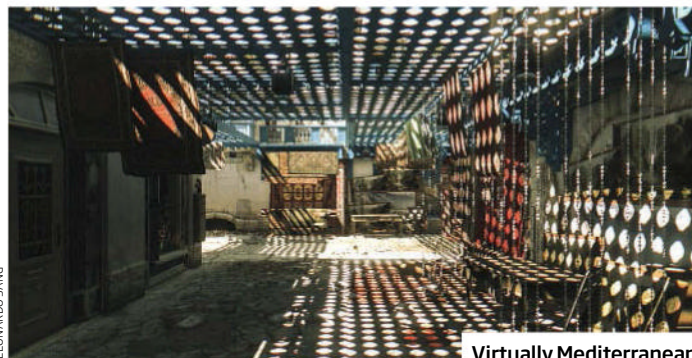
But it is not just space sims that have sightseers. As graphics have become ever more realistic, photographers have started to document virtual worlds.

Leonardo Sang, a graphic artist and photographer based in São Paulo, Brazil, realised that his love

of photography could spill over into the games he plays. "Sometimes I just roam around and look," he says.

Sang is part of a growing community of virtual photographers. Duncan Harris – whose Dead End Thrills website contains hundreds of carefully composed screenshots – has become well known. And there is a Flickr group dedicated to video-game tourism.

One of Sang's favourite shots was taken in *Dying Light*, a game set in a zombie-ridden post-apocalyptic world. The image shows an alleyway speckled with light and shadow (below). "It has



Virtually Mediterranean

this Mediterranean feeling, a little tapestry market," he says.

Virtual photographers such as Sang particularly enjoy the freedom of open-world games. Sang will happily spend hours wandering the streets in a game such as *Grand Theft Auto V* – set in a fictional version of Los Angeles – just looking for subjects that will make a striking composition.

Endless exploration

The algorithmically generated world of *Minecraft* is so vast that you could walk for 20 years among the hills, valleys and rivers and never reach the edge. One explorer who set out in 2011 is still walking. Other players prefer to churn through several random worlds in a sitting, looking for those where algorithms have spawned exotic geographical features.

For several years, communities of *Minecraft* explorers have shared pictures and stories about the randomly generated landscapes the game conjures for them. One group styles itself as the internet's largest community of virtual cartographers.

In *Elite*, explorers can earn huge sums by selling information about the regions of space they visit, such as what planets have valuable resources or which stars might be used for refuelling.

There is a lot to see. If each of *Elite*'s half a million players explored 1000 star systems this year, there would still be 399,500,000,000 stars left undiscovered. "At that rate, it would take 800 years to map them all," Proudfoot says.

Since that first trip, he has travelled to dozens of nebulae and even visited Sagittarius A*, the supermassive black hole at the centre of the Milky Way. But it is a small, Earth-like planet with icy rings that he spotted out near Barnard's Loop that sticks with him. "I'm sure I was the first person to see it," he says. "It's an image I have never forgotten." ■

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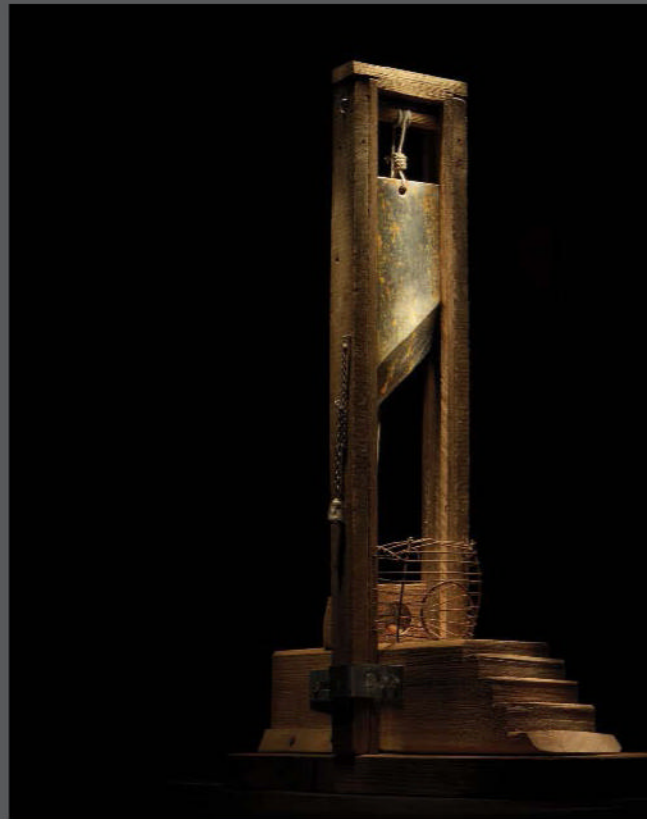
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Mousetrap evolution

IF YOU are scanning these pictures for the “ACME corporation” logo, stop. Although these instruments of torture could easily be imagined in the hands of a cartoon villain, they are real mousetraps developed through the ages.

They might seem comical – after all, there is something very cartoon-like about a mouse being killed by a tiny French guillotine (middle, top) or captured in a jar accessed via a ladder (middle, bottom). But what photographers Heidi and Hans-Jürgen Koch wanted to capture was the creativity and imagination of inventors, dating back to our Stone Age ancestors (right, bottom), in an effort to protect their food from the furry menaces.

Some went for the brutal route exemplified by the classic snap trap, patented in 1894 by William C. Hooker, or the similar “Little Nipper”, patented in 1899 by James Henry Atkinson. Others designed more creative death traps, using nails to crush or stab the captured mouse (left, bottom), wires to strangle it (left, middle) or a block of wood to crush it (right, middle).

The humane trap was the brainchild of Austin Kness in the 1920s, who designed a mousetrap that could capture several live mice without using bait. The German mash-pot trap depicted here (middle, bottom) is an example of this, using a flour-covered ladder to entice the mouse to fall into the open mash-pot.

There have been more than 4000 patent applications filed for mousetraps – the most for any type of device, apparently. But despite these ingenious, or perhaps crazy, contraptions, our furry adversaries are still around, biting our bread, scratching our cupboards and leaving droppings on our floors. It seems that Jerry always has the last laugh. Rachel David

Photographers

Heidi and Hans-Jürgen Koch [eyevine
lifeformphotography.com](http://eyevine.lifeformphotography.com)

Category error

Is Pluto a full planet or a dwarf? Such distinctions are becoming meaningless as we discover a menagerie of celestial objects, says **Jeff Hecht**

INCREDIBLE images of Pluto captured by the New Horizons probe have reignited the long-running debate over its official status. Controllers of the craft cheered when NASA chief Charles Bolden pointedly referred to Pluto as a planet, not a dwarf planet, the label given when it was downgraded by the International Astronomical Union in 2006.

To advocates of full-planet status, photos showing ice mountains and a lack of craters make Pluto look like a bona fide world with active geology.

But the question of how to classify it is more than an emotional one for those of us who grew up in a solar system with nine planets. It goes to the heart of what to do when science keeps changing our view of the universe.

Classification is one of the key foundations of science. Biological classification helped to lay the



groundwork for understanding evolution. And classification of objects in the heavens helped to create the science of astronomy. Observers recognised that planets moved regularly through the sky, while the stars stayed put. They saw that comets and meteors were transient objects, and Edmond Halley's discovery of a periodic comet was a milestone in fathoming the solar system.

As a result, through most of the 20th century, celestial bodies were neatly sorted into distinct classes. Planets were large objects that orbited the sun; asteroids were smaller, rocky things that seemed like rubble from planet-building. Comets were dirty snowballs quite distinct from asteroids.

But the more astronomers learned, the messier things got. In the 1990s, new telescopes began finding what looked like smaller siblings in Pluto's zone.

Very alien intelligence

A new search for ET may well find something rather unexpected, says **Martin Rees**

AS WE discover planets across our galaxy – and perhaps beyond – it is right that the search for alien entities should be stepped up. Breakthrough Listen, a \$100-million project led by the Russian billionaire and venture capitalist Yuri Milner, is set to reinvestigate the hunt for ET.

The search for planets orbiting

other stars usually focuses on finding and scrutinising those that resemble Earth. And while it would be fascinating to find evidence for a biosphere on such a world, we should be open-minded about advanced entities existing in very different environments.

Why? Many people now believe that machine intelligence will

eventually surpass human capabilities. Even if this is centuries away on Earth, it is clear that technology advances in an instant compared with the Darwinian selection that led to us.

We should accept that the era of organic intelligence is relatively short, and will be followed by a much longer era dominated by inorganic intelligences. Humans and our intellectual achievements will be a mere precursor to the

“Biological brains will be a brief prelude to the more powerful intellects of the inorganic, post-human era”

deeper cogitations of a machine-dominated culture.

Moreover, advanced AI would not be confined to Earth-like biospheres. Indeed, they are far from optimal. Interplanetary and interstellar space is where robotic fabricators will have the grandest scope for construction, and where non-biological “brains” may have insights as incomprehensible to us as string theory is to a mouse.

Abstract thinking by biological brains has underpinned all culture and science on Earth. But this activity, spanning tens of millennia at most, will be a brief prelude to the more powerful intellects of the inorganic,

Pluto was demoted to a dwarf planet, largely because it did not have an orbital region all to itself.

Other traditional astronomical categories have been blurred too. As we looked at comets and asteroids more closely, the distinctions got hazier. Objects that looked like asteroids were found to have wispy tails, as if they were faded comets. Exoplanets are complicating the picture too: we are finding planetary systems that are far more diverse than ours. No sharp line seems to separate rocky planets from gas and ice giants; instead, we find an intermediate zone of “super-Earths”. And other weird worlds defy definition.

Seeing Pluto up close reminds us that the universe, like life on Earth, is a continuum. It was easy to draw dividing lines when we didn’t know much. Without ample fossils, we could not see how dinosaurs evolved into birds. Likewise, without a large sample of astronomical bodies, we could not see that what we thought were distinct classes in fact overlap.

The universe does not make hard and fast distinctions. So let’s not get too hung up on the ones we create for our convenience. ■

Jeff Hecht is a consultant for *New Scientist*

post-human era. Evolution on other worlds orbiting stars older than the sun could have had a head start. If so, then ET is likely to have long ago transitioned beyond the organic stage. So it won’t be human-like minds that we are most likely to encounter, but machine intelligences.

Therefore, if extraterrestrial intelligence exists, it will most probably be non-human-like, and we ought to be looking for it in a non-Earthlike environment. ■

Martin Rees is an astronomer at the University of Cambridge and the UK’s Astronomer Royal. He has been invited to chair the Breakthrough Listen project

ONE MINUTE INTERVIEW

How our lies hit a peak

The ease with which we spin lies follows a distinct pattern as we age, says **Bruno Verschuere**, who finds ways to spot liars



PROFILE

Bruno Verschuere is an associate professor of forensic psychology at the University of Amsterdam in the Netherlands, where he investigates how people lie and deceive. He is developing new techniques for lie detection

Does our capacity to lie change?

There are age-related differences in our ability to lie, and these are in line with the development of the prefrontal cortex – a part of the brain involved in controlling our behaviour. It doesn’t fully develop until young adulthood, after which it gradually declines. We predicted that the ability to lie would also follow this pattern and that’s what we found. We focus on the cognition of lying – how hard it is to lie, which we can judge by how long it takes a person to concoct a false statement. There’s a lot of evidence suggesting lying is more cognitively demanding than telling the truth.

Isn’t there more to lying than being able to keep yourself from telling the truth?

Oh yes. Lying is a very complex phenomenon. There are many factors involved – the motivation to lie, emotions, social factors and so on. We focus on the cognitive aspect of lying. It’s a narrow scope, but that allows us to apply science to the issue.

How can you find out how frequently a person lies in everyday life?

We use a questionnaire. It sounds silly to ask people to tell us honestly how often they lie. But in another study we found that people who report lying a lot are also more likely to cheat in a separate task, so that gave us confidence in this approach.

How often do people lie?

The average is about two lies per day. What’s interesting is the age-related differences. Young children report lying on average 1.5 times a day, but that increases as they get older. By the time they’re adults, they lie nearly 3 times a day. Then lying frequency declines with age – seniors tell as few lies as young children.

Why do young adults lie more often?

I’m speculating, but it probably has something to do with gaining autonomy at that age – becoming an individual and separating themselves from their parents or teachers. They probably lie more to authority figures.

How can you apply what you are discovering?

We are mapping the conditions under which people find it hard to lie, so that we can exploit these conditions to develop lie-detection tests. You might need more advanced strategies for people in the adolescent to young-adult age range, for example. Young adults find it easier to lie, so we’d expect them to be more convincing.

How might you improve lie-detection tests?

We’ve been developing computerised tests where we try to see whether a person is lying or not, based on how fast they respond. Another cognitive approach might be to make lying more difficult. You could ask them to tell their story in reverse order, for example, or ask questions that they wouldn’t expect. For a long time, lie detection has focused on techniques that are based on stress. But these gave a lot of false positives, because truth-tellers can get as stressed as liars.

Interview by Jessica Hamzelou

Welcome to the bionic dawn

Hugh Herr plans to connect next-generation prosthetic devices and their human users in a seamless and profound way

Tell me about your bionic legs...

I have a company that produces what I'm wearing: the BiOM Ankle System. For the first time in history we've normalised walking speed and its energy cost. In other words, if you simply measure a user's speed and metabolic energy expenditure, you can't tell whether they have bionic legs or biological legs. That's especially important because conventional technology used on people with leg amputation makes them limp, which causes musculoskeletal stresses that lead to joint disease and many other secondary conditions. True limb bionics eliminate limping and solve these very costly secondary conditions. Typically when we fit the BiOM prosthesis to a person, if they have hip pain, knee pain or back pain it is reduced in days.

Could such bionics benefit people in general?

Actually, we have developed bionic technology for people with complete biological limbs. Last year, we were the first research group to build an autonomous leg exoskeleton that significantly reduces the metabolic cost of walking to a person without a leg condition. It's an artificial calf muscle, which supplies about 80 per cent of the power to walk. So a person with a normal physiology could put on these exoskeletons and walk using substantially less energy.

It's so profound in its augmentation that if you wear it just for 20 minutes and take it off, your legs feel heavy and awkward.

Who do you see using these?

Soldiers, hikers, athletes, anyone. Imagine a world where our physicality doesn't decrease as we age. The number one reason your grandparents can't get around is knee

osteoarthritis, and the biomechanical cause is believed to be a degradation of calf muscle power. With bionics, we can put 18-year-old calf muscles in (or on) everyone, regardless of their age, and potentially solve this big mobility problem in the elderly. If our biology continues to have the typical age-related degeneration, bionic technology can make up the differential.

The best marathon time of your life could be when you're 60, after you started running marathons when you were 20. Imagine how such future technology will affect running times, jumping heights and all types of athletic performances.

Isn't it cheating to use technology like that?

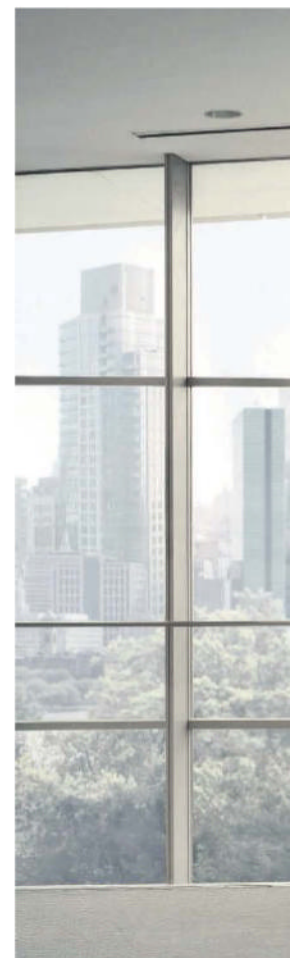
The idea here is to use technology to maintain a human's inherent biological physicality, a notion that most people would accept. One can imagine a world where people wear bionics just so that when they run and train they don't have enormous stresses on their biological joints. We are clueless about our own bodies. We have no idea when we're about to injure ourselves. Sensors in the machines can give us that awareness and tell us that we need to stop or do something different – or they can lower the physical stress for us.

Tell me about your vision to connect bionic devices directly to the human nervous system.

Prostheses and exoskeletons are conventionally controlled by electrodes on the skin that detect the electrical activity of muscles. But this approach is kind of a laboratory trick, with limited functionality for clinical applications. One reason is that if I left here and ran two miles, I could fill a whole glass with my sweat. Current skin-surface

PROFILE

Hugh Herr runs the Biomechatronics research group at the MIT Media Lab and co-founded the Center for Extreme Bionics. His lower legs were amputated following frostbite sustained in a climbing incident



interfaces will not survive, or produce consistent signals, in such a harsh environment. So our goal is to get information in and out of the peripheral nervous system in a more direct manner – invasively.

Aren't other groups already doing this, by implanting electrodes directly into nerves?

The problem with approaches that pierce the nerve is that nerves complain loudly. It's just not a viable, sustainable option in my view.

So what's your solution?

What we are discovering is that you don't need to pierce the nerve, because the peripheral system is remarkably flexible. If you take a muscle that doesn't have a nerve and then you place a cut nerve close to that muscle, the nerve will grow and sprout and innervate the muscle. It's a very robust and repeatable phenomenon. So we are creating an interface that exploits biology by growing nervous tissue through or around synthetic materials, closing the loop between human and



CHRIS CRISMAN

machine. The interface would detect nerve signals that reveal a user's intent to move a prosthesis, for example, or could transmit sensory information from a prosthesis into the body through the nerve.

How would the signals from the nerve connect to the artificial limb?

That's a key question. Once you have an interface to the nerve, you're going to end up with a bundle of wires, so how do you get the information in and out of the body? Many researchers are pursuing a wireless approach, where implanted electronics communicate wirelessly with a wearable robot.

I think it's compelling to consider wired approaches, because you could transmit information at an enormous rate. Then there would be an external skin patch where all the communication and processing takes place. And you could make the patch beautiful; it could be like a tattoo, right? In my own body I would want such a patch on my thigh. I'd have wires in and out of my peripheral

nervous system passing to and from the patch, providing two-way, wired connectivity to any external machine.

What other conditions might your devices be useful for?

We're also doing work with other limb disabilities, such as paralysis. For a person with a spinal cord lesion, you could in

"Our interface uses biology to close the loop between human and machine"

principle put stimulation technology on nerves for muscle activation, along with muscle sensors that we're also working on to measure muscle dynamics. You could have a synthetic, external spinal cord.

This sounds incredibly futuristic...

Bionics is just getting started. What I'm wearing here is going to be laughable

20 years from now – absolutely laughable. So if you think stuff is cool now, it will become extraordinary – and disability will end, I'd say, by the end of this century. And I think that's a very conservative statement. At the rate technology is progressing, most disability will be gone in 50 years.

Some people might take offence at the idea of having to fix all disability.

I'm upset today when you have a human being who is blind, can't hear, can't move. Such human limitation is what I find deeply offensive. If a person desires to be hearing impaired and loves that culture, wonderful. A person can choose not to use hearing prostheses. But if a person wishes to hear Mozart, I think society should work hard to give them that freedom. It's about human rights. If a person wants to run but has paralysed limbs, let's give her that right. ■

Interview by Catherine de Lange

Bitter truth

Fruit and veg are getting tastier... at the expense of our health.
Marta Zaraska reports





WHERE have all the white grapefruit gone? When I was a kid, they were almost the only kind around, but today white grapefruit are hard to find in my local shops, often replaced by sweeter pink or red varieties.

I'm not imagining it. Thirty years ago, Florida, the grapefruit capital of North America, produced 27 million boxes of white and 23 million boxes of the coloured varieties. Today, they ship more than twice as many red and pink grapefruit as they do whites ones. And it turns out grapefruit is a bellwether of a more insidious trend. It affects much of the fresh produce aisle, from cauliflower to potatoes, tomatoes and juices. Our fruit and vegetables are becoming less bitter.

On the face of it, reducing bitterness in foods sounds like a great idea. Wouldn't it be nice if broccoli were always mild and sweet? Supermarkets are already advertising milder Brussels sprouts as "kid friendly". But there is a catch. The same chemicals that make fruit and veg bitter also imbue them with many of their health benefits. When scientists talk about the healthiness of green tea, dark chocolate, red wine or broccoli, much of what they are talking about is due to bitter chemicals called phytonutrients.

To satisfy our love of sweetness, food manufacturers are now removing many of these substances, causing some people to worry that we are turning bitter fruit and veg into the junk foods of the fresh produce aisle. "Eating fruits and vegetables without phytochemicals would in many ways be analogous to drinking the empty calories of a can of soda," says Jed Fahey a molecular scientist at Johns Hopkins School of Medicine in Baltimore, Maryland. "Yes, you could survive on de-bittered fruits and vegetables, and they would help maintain life, but not good health." So if our preference for sweet over bitter is prompting the food industry to strip some foods of the very chemicals that make them good for us, what's to be done? And how can we train our taste buds to better enjoy bitter?

It makes sense that as consumers we favour sweet ingredients – we have evolved to do so. Sweet foods hold the promise of a ready supply of energy. Salty food contains sodium, necessary for our bodies to function properly. Bitter, on the other hand, suggests toxicity, which is why our natural reaction is to want to spit it out. Bitter phytonutrients act as a natural pesticide, protecting plants against all kinds of enemies, from bacteria to insects and cows. Thousands of these nutrients have been

identified so far, giving the bitter tang to familiar foodstuffs such as Brussels sprouts and coffee.

But despite phytonutrients being toxic in large doses, a growing body of evidence suggests that small doses can confer a host of health benefits. The elusive white grapefruit is a prime example. Its most prominent phytonutrient is ultra-bitter naringin, which turns out to have anti-ulcer and anti-inflammatory properties. Naringin can also inhibit the growth of breast cancer cells, and induces cervical cancer cells to commit suicide. The sweeter pink and red varieties have substantially less of the stuff.

The mechanism at work is known as hormesis – simply put, it's the idea that what doesn't kill you makes you stronger.

"The reason bitter phytonutrients are cancer preventing is that they can destroy cells. They are healthy because they are toxic," says Adam Drewnowski, an epidemiologist who studies nutrition at the University of Washington in Seattle. One study, for example, found that eating a diet rich in quercetin, found in green tea, broccoli and red wine, might help protect against lung cancer, especially in heavy smokers.

Sweet tooth

And the list of phytonutrients thought to have anticancer properties is growing. It now includes sinigrin – one of a group called glucosinolates, which give the bitter edge to Brussels sprouts, cauliflower, cabbage and kale. There's also genistein in soya beans, sulforaphane in broccoli, plus potatoes have solanine and tomatoes have tomatine.

Further explanation of the health benefits of phytonutrients may be their antioxidant properties. Antioxidant supplements have come under some scrutiny in recent years. But the thinking is that when eaten as whole foods, rather than supplements, the phytonutrients in bitter fruit and veg trigger our internal antioxidant system to kick in. "These compounds can activate the expression of antioxidant genes that do have the ability to remove oxidants and other potentially toxic compounds," says Henry Jay Forman of the University of Southern California.

A dose of the bitter stuff seems to have benefits for heart health, too. Phytonutrients in cocoa, coffee or berries can reduce the risk of cardiovascular disease – and not only due to their antioxidant and anti-inflammatory properties. They also help to prevent the build-up of plaque in the arteries. ➤

Even so, we evolved to recoil at the taste of substances that might poison us, rather than favour them for any benefits relating to cancer or heart disease, which usually affect us after we have reproduced. This aversion to bitterness is especially strong in around a third of us (see box, “Are you a supertaster?”). “Because they are bitter, for years we have been removing phytonutrients from the food supply,” says Drewnowski.

As a result, what we eat today is noticeably less bitter than the food our parents and grandparents ate even a few decades ago, says Peter van der Toorn, who leads the vegetable breeding division of Syngenta in the Netherlands. Brussels sprouts are a good example. “We still have bitter sprouts on the market, but the majority of what’s introduced these days is milder.”

Downgraded drinks

One way growers do it is to breed the offending compounds out. In fact, humans have been doing this since the dawn of agriculture. Take tomatoes, a fruit many of us wouldn’t even think of as bitter today. One wild species indigenous to Peru can contain 166 times as much bitter tomatine as the mild varieties we normally find on supermarket shelves.

When breeding and growing conditions are not enough, manufacturers can also sometimes remove bitter compounds later on, instead. They call this process de-bittering.

Citrus juices, for example, naturally contain high amounts of phytonutrients such as limonin, naringin or naringenin. “Most juice manufacturers make a concerted effort to limit bitterness,” says Russell Rouseff, a food chemist at the University of Florida. One method involves passing the juice through a bead-like resin that filters out bitter molecules. This can reduce the amount of naringin in grapefruit juice by as much as 64.5 per cent. Surprisingly, home-made freshly squeezed orange juice contains on average fewer healthy phytonutrients than do commercial freshly squeezed juices. That’s because these producers scrape out more phytonutrient-rich peel oils into the drink.

The more we learn about the role of bitter in our diets, the further the effects seem to reach. Drinking cocoa high in flavanols over a period of four weeks has been shown to significantly increase the presence of bacteria in the gut that boost digestion and immune function. These benefits weren’t seen with “dutched” cocoa, which has had the flavanols removed.









Some de-bittering processes are stripping our food not only of the health benefits bestowed by phytonutrients, but also essential vitamins. What’s more, skimping

on bitter could have unwanted effects on our waistlines. “Bitter receptors, which are amazingly spread along the gastrointestinal tract and not only on the tongue, are now known to play a pivotal role in many gastrointestinal mechanisms, such as appetite regulation,” says Daniele Del Rio at the University of Parma in Italy. “Therefore, getting rid of bitter compounds, besides depriving our body of potentially protective phytonutrients, is also impairing our capacity to regulate food intake.”

Many scientists working in the field believe that the food industry has a responsibility to make sure that phytonutrients are preserved in our food supply. It would be better for our

BOILING AWAY THE GOODNESS

Many vegetables contain glucosinolates, which may have anticancer benefits. Cooking diminishes the amount

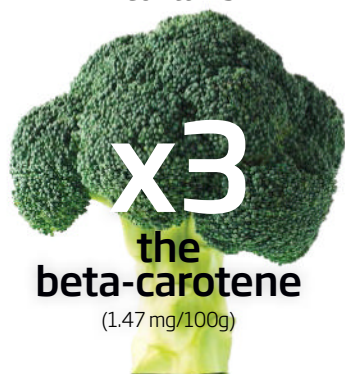
	RAW	BOILED
White cabbage	 108.9 mg/100g	 78.6 mg/100g
Brussels sprouts	 226.2 mg/100g	 123.7 mg/100g
Cauliflower	 62 mg/100g	 42 mg/100g
Turnip/swede	 56 mg/100g	 29.1 mg/100g

Cooking, on average, decreases glucosinolates by

30%

NUTRIENT-RICH VARIETIES

Broccoli
(Atlantic variety)
contains



of Packman variety
(0.49 mg/100g)

Onion
(yellow Savannah Sweet variety)
contains over



than white Contessa variety
(0.54 mg/kg)

SOURCES: BROCCOLI - JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY · DOI: 10.1021/JF981015B; ONIONS - J. AMER. SOC. HORT. SCI. 120(6):909-913. 1995; GRAPEFRUIT - JOURNAL OF FOOD COMPOSITION AND ANALYSIS 19 (2006) 574-580; TOMATOES - METABOLISM DOI: 10.1016/J.METABOL.2008.03.001

overall health if we stopped de-bittering our juices and growing increasingly less-bitter vegetables, Fahey says. This would also help safeguard the genetic diversity of our fruit and veg, which is being lost “at an astonishing rate”.

Such a message isn’t always welcome. Some of those working in the food industry argue that they are simply responding to customer needs.

Yet, as consumers become more interested in the health benefits of bitter phytonutrients, the industry is starting to offer foods enriched with these compounds. Beneforte broccoli, for instance, is bred in the UK for its high content of cancer-fighting sulforaphane.

You could argue that a trend towards milder,

White grapefruit
contains



(26.96 mg/100g)
than red and pink grapefruit
(17.9 mg/100g)

Wild tomato
(*Lycopersicon esculentum var cerasiforme*)
contains up to

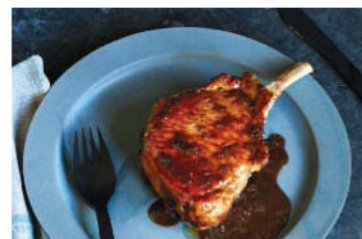


(up to 5000 mg/kg)
than modern sweet-fruited
tomato cultivars (30 mg/kg)

sweeter produce is beneficial if it means people eat more fruit and vegetables. “If someone who normally only eats fresh fruit or veg once every three days now eats one a day, because of the less bitter taste, would that be a desirable outcome? I suspect that it might,” says Fahey. That’s especially true of children, who generally have a particularly strong aversion to bitter foods.

Still, this approach is not ideal. “Broccoli, for example, will have a number of things that are good for health: low energy density, fibre, vitamin C. But it also has a number of antioxidant phytonutrients, and if those are bred out, the health function of broccoli will diminish,” Drewnowski says.

COOK BITTER BETTER



Using bitter food will make you a better cook, says chef Jennifer McLagan

Understanding the role of bitter is an essential skill for a cook. Bitter is vital for the harmony of a recipe and crucial to the composition of a meal. It enhances the flavours in a dish, subtly adding complexity and depth, often without any marked bitter taste.

Bitterness gets your gastric juices flowing, so beginning a meal with something bitter makes good sense. This could be a bitter aperitif, or a first course with a touch of bitterness - bitter greens stirred into a soup or pasta for example. Rich, fatty dishes can be tempered and rendered more digestible by pairing them with bitter green vegetables. And a little bitterness in a multi-course meal will help cleanse your palate. Try chicory salad for example (see link to recipes, below). And if you find chicory too bitter, use bacon fat or anchovies in the dressing, as both fat and salt suppress the bitterness.

At the end of a meal, a rich dessert with a hint of bitterness is less cloying than a sugary sweet one. Try a dusting of bitter cocoa powder rather than powdered sugar on a chocolate dessert.

Even the plates you use and the music you play at dinner can alter your perceptions of the food’s bitterness. Serve the chicory salad on a round plate and it will taste less bitter than if you use a square one.

Avoid low-pitched, solemn music played on brass instruments, unless you want the food to seem more bitter. Instead, choose bright, high-pitched piano music, as it will diminish your impression of bitterness. Taste, after all, is created in the brain.

Bitter: A Taste of the World’s Most Dangerous Flavour by Jennifer McLagan, published by Jacqui Small, £25.00
For recipes see: bit.ly/bitterfood

ARE YOU A SUPERTASTER?

In 1931, chemist Arthur Fox accidentally spilled a substance called phenylthiocarbamide (PTC) in his lab. When his colleague complained about the horrible-tasting stuff floating in the air, Fox was puzzled – he couldn't smell a thing. To prove his colleague wrong he put some of the white powder on his tongue – and found he could not taste it at all. This exchange prompted Fox to study the taste of PTC.

We now know that about 30 per cent of us are “supertasters” – finding substances like PTC (or PROP, a modern, safer substitute of PTC) unbearably bitter. Meanwhile, about 20 per cent of us can't taste the bitterness of PROP at all – so-called “non-tasters” – with the remaining 50 percent falling somewhere in between.

Supertasters tend to be people with a sweet tooth, preferring milk chocolate to dark and disliking coffee and bitter vegetables like sprouts, cabbage and spinach.

To find out whether you are a supertaster, take a close look at your tongue. Supertasters have far more fungiform papillae – the mushroom-like structures on which taste buds are perched. Apply blue food colouring to the tip of your tongue and put a 6-millimetre-diameter doughnut-shaped sticky label onto the blotch (the kind use to reinforce hole-punched pages). Then, with a magnifying glass, count the raised spots inside the circle. These are your fungiform papillae. The blue food colouring doesn't stain them, so they look lighter in colour than the rest of the tongue and can be seen quite easily. If you have less than 15, you are a “non-taster”, 16 to 39 makes you a “regular taster” and 40 or more is evidence you're a “supertaster”.



“Children need to be offered a new food 10 to 15 times before they start liking it”

ALEXANDER KENT

So it would be even better to find ways to learn to love bitter food a little bit more. One approach is to start young – as with babies fed hydrolysed casein baby formula, a substance so potent that many adults vomit after trying it. Babies who are allergic to cow's milk are given this formula, and it's healthy but bitter. “This stuff is absolutely awful,” says Gary Beauchamp from Monell Chemical Senses Center in Philadelphia. “But if babies are fed it early in life, they don't mind it, and they will like bitter for the rest of their lives.” That's been borne out in research showing that kids fed the casein formula at a young age enjoy broccoli more as toddlers than those who grew up on regular, sweet milk formulas.

Acquired taste

With a bit of persistence older children will take to bitter, too, according to research that shows they have to be offered a new food 10 to 15 times before they start liking it. “The child doesn't even have to eat the food. Repeated exposure is all parents need to do,” says psychologist Gemma Witcomb, who studies children's eating habits at Loughborough University in the UK.

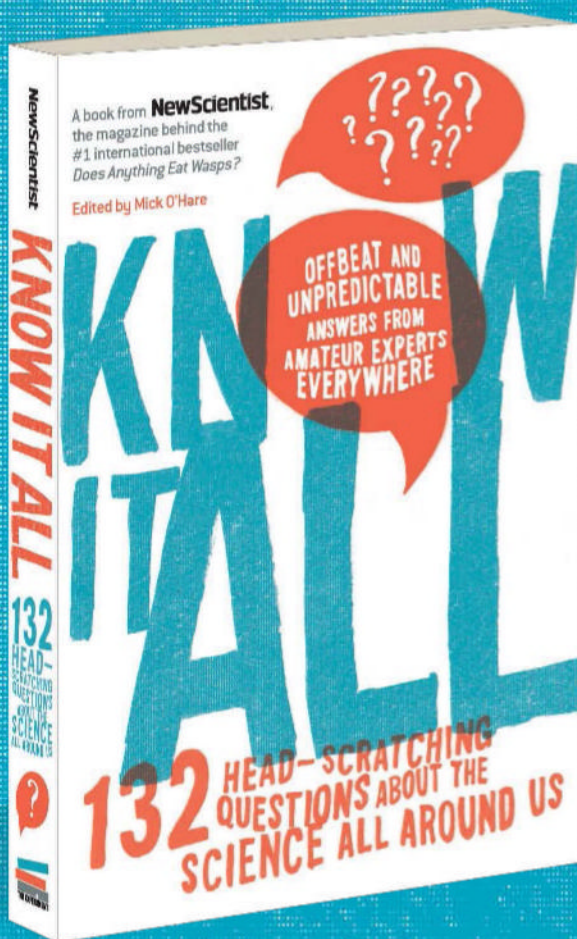
Adults, too, can change their ways, not least because an affinity for bitter is partly cultural. The first sip of coffee or beer for most people is lip-curling, but many of us learn to love them because their bitterness is paired with a desirable hit: caffeine or alcohol.

A similar approach could help make more virtuous bitter foods more palatable too, thanks to something called flavour-flavour learning – pairing something you don't like with something you do like. Both children and adults who drank grapefruit juice mixed with sugar, and ate broccoli with sugar sprinkled on top, learned to like the bitter foods, even without the sugar. And there are ways to cook food to balance out or compliment the bitter tastes, (see “Cook bitter better”, p 29).

This goes to show that with a bit of effort we can all change our approach to bitter food. As for sourcing the right ingredients, keep an eye out for heritage varieties, with all their healthy bitterness (see “Nutrient-rich varieties”, p 29). But more than anything, just let your taste buds guide you. Whether you learn to like the non-dutched cocoa full of flavanols, or come to seek out white grapefruit that's stuffed with naringin – the more bitter the better. ■

Marta Zaraska is a writer based in France

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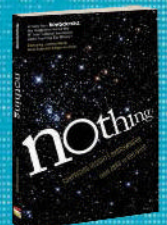
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Home, sweet exomoon

Forget planets – there’s a new place to look for life out there, says **Andy Ridgway**

THE diminutive sun set hours ago, but a giant orb suspended in the sky still suffuses the scene with a low, orange-red reflected glow. The air is thick with volcanic soot, yet surprising activity is discernible through the fog. Large-eyed predators roam the landscape, padding through black, wide-leaved foliage.

A weak sunrise inches over the horizon, as yet another seismic rumble ripples through the surface. A faint new day will soon dawn on this moon of a gas-giant planet, orbiting a red dwarf star thousands of light years from Earth.

Lunar life is a staple of science fiction. Lush imagined moons such as Endor, forested home of the Ewoks in *Star Wars*, or the magical Pandora of *Avatar* readily capture our imaginations. Perhaps that’s because they represent something familiar in many ways, but altogether different.

An Endor or Pandora is possibly too much to ask for, but something like the gloomy, volcanic moon orbiting a gas giant might not be too wide of the mark. And as we learn more about planetary systems – in our solar system and elsewhere – there’s a growing feeling that, in the search for alien life, we are better off looking not at planets, but at moons. And

although no “exomoon” in another solar system has been discovered quite yet, we could be just the blink of a telescope away.

The possibility of discovering alien life is one big reason why the discovery of exoplanets orbiting other stars has generated so much excitement over the past two decades. Instruments such as NASA’s Kepler space telescope, the most prolific of planet hunters, have been providing us with an almost constant stream of other worlds, with the confirmed total now pushing 2000.

The search continues for Earth’s twin – or at least, any form of habitable planet. There have been some close calls, but in many ways exomoons are more promising. Partly that’s a pure numbers game. Our solar system has only eight major planets (and only one habitable one), but between them they have 168 known moons. If our backyard is anything to go by, there are likely to be far more moons than planets out there.

The crucial hunting ground for life has conventionally been a star’s so-called habitable zone – the thin girdle around it where water, life’s solvent, can exist in liquid form. Kepler has shown us that the most abundant planets orbiting here aren’t small, life-friendly rocks like Earth, but gas giants the size of Jupiter or bigger. It’s hard to conceive of such planets harbouring life, but easy to think they might have rocky moons that can. “Moons might even outnumber terrestrial planets here and therefore be the most abundant type of inhabited world in the universe,” says



ENDOMOONS

While excitement grows about the chances of finding life on “exomoons” in other solar systems (see main story), we haven’t yet exhausted the possibilities offered by the icy moons of our own outer solar system: the endomoons.

ENCELADUS: Saturn

Radius: 252 km

Average distance from sun: 1.4 billion km

Environment for life: A hidden ocean of salty water perhaps the size of Lake Superior, most obviously apparent through geysers shooting through the moon’s icy surface near its south pole. Earlier this year NASA’s Cassini probe found evidence the ocean might be warmed and supplied with minerals through undersea hydrothermal vents.

Possible life: Anything near these vents may resemble microbial life that lurks near Earth’s deep-sea vents – a possible cradle for life here.

EUROPA: Jupiter

Radius: 1561 km

Average distance from sun: 780 million km

Environment for life: Ridges criss-crossing Europa’s surface might be generated by tidal forces warming a voluminous subsurface ocean that has probably been around for 4 billion years.

Possible life: One of the closest analogues for Europa’s ocean is the subglacial Lake Whillans in western Antarctica, home to nearly 4000 species of microbe. But Europa’s waters are likely to be alkaline and salty, chemically more akin to soda lakes in eastern Africa – so any microbes there are likely to be unique.

GANYMEDE: Jupiter

Radius: 2634 km

Average distance from sun: 780 million km

Environment for life: In March, the Hubble Space Telescope provided evidence that a vast ocean of salty water – amounting to perhaps more than all of Earth’s surface water – exists beneath the icy surface of the solar system’s largest moon.

Possible life: Microbial ocean-dwelling lifeforms.

TITAN: Saturn

Radius: 2576 km

Average distance from sun: 1.4 billion km

Environment for life: Titan’s frigid surface has seas of liquid methane. Its atmosphere is rich in organic compounds formed when sunlight breaks down methane – but could some form of life also be generating fresh methane here?

Possible life: A recent study suggests cells on Titan would have methane-based membranes, rather than the lipid bilayers of our cells.

exomoon hunter René Heller of McMaster University in Hamilton, Ontario, Canada. So the search is on – with the added inducement of having your name associated with that first discovery. “You really want to find an exomoon rather than planet number 4350,” says Heller.

But while there has been the odd unconfirmed candidate in recent years, there has been no definite exomoon sighting yet. “It’s mostly because they are probably very small,” says David Kipping of the Harvard-Smithsonian Center for Astrophysics.

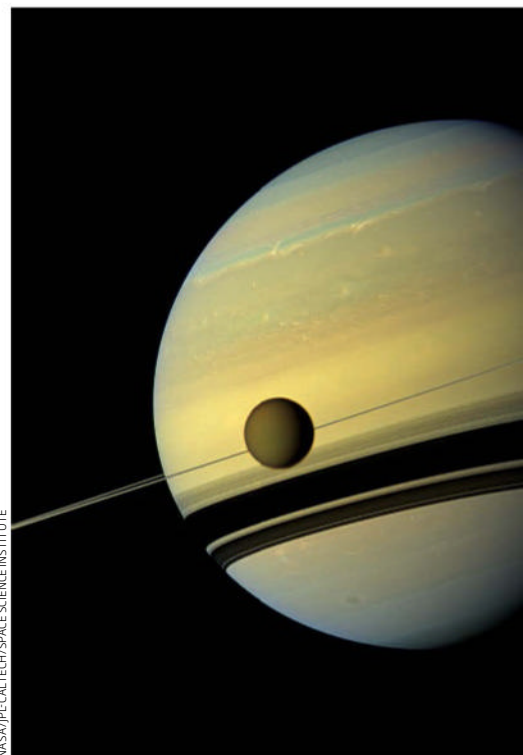
Kepler, for example, finds exoplanets by looking for the dip in a star’s brightness caused by an orbiting body transiting across its face. The size of this dip diminishes with the circumference of the transiting body, so something half the size will be four times harder to see. Kepler was designed to find Earth-sized planets; the largest moons in our solar system, Jupiter’s Ganymede and Saturn’s Titan, each have a radius about 40 per cent of Earth’s. If that size is typical, exomoons are right at the limits of existing telescopes.

But it’s not just size. Planets sail across their star at nicely regular intervals, but a moon can be behind its planet, in front of it, or at some point to the side, making any additional small dimming effect appear irregularly (see “Moon spotting”, below). “It could happen a few hours before or after the transit, and sometimes early and sometimes late,” says Kipping.

Nevertheless, exomoon hunters are growing in confidence. “I think David Kipping and I would agree that maybe we are at the stage that the exoplanet hunts were at in the late 80s and early 90s,” says Heller. “The

techniques are there, so we now have to search for these moons.”

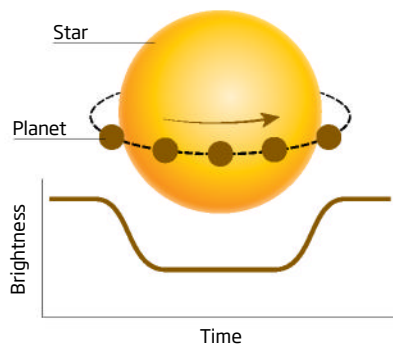
Kipping’s Hunt for Exomoons with Kepler project is perhaps the furthest advanced. His team starts with Kepler information on known planets and painstakingly develops predictions for a range of effects such as when a possible moon would transit and how its gravity might affect the planet’s speed at certain points, changing the duration of its transits. They then search for hints of such things in the data. “Each of these effects may only just be detectable by themselves,” says Kipping. But see several of them with the same planet, and you might be on to something.



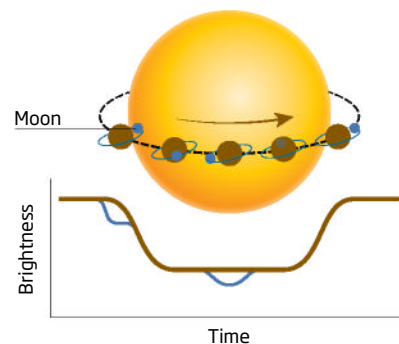
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Moon spotting

The signature of a moon orbiting a planet in another solar system is difficult to see



A planet causes a regular dip in the light reaching us from a star, so it is fairly easy to detect



A moon orbiting that planet will cause additional small dimmings – but at widely varying times depending on where it is in its orbit

Saturn's moon Titan
might harbour exotic
microbial life



STUART FRANKLIN / MAGNUM

Kipping has enlisted NASA's Pleiades supercomputer to model 57 possible planetary systems, and hopes to have 300 completed by the end of the year. Their technique should be sensitive enough to discover the smallest exomoons capable of sustaining an Earth-like atmosphere in at least 1 in 4 of the systems the team surveys, if they exist. "In terms of moons that could have life on them, and by that I mean Earth-like life, we are already definitively sensitive," Kipping says. "When we've finished this survey, I will be able to tell you how often Pandora actually exists."

Heller's own modelling, meanwhile, suggests a planet several times the size of

Jupiter could have a moon the size of Mars – and that should be big enough for Kepler to spot. His team has developed a technique that involves comparing multiple transits of the same planet and looking for any variations in light that might indicate the presence of a third body. He is currently applying for funding to use the approach on Kepler data.

In June, meanwhile, Joaquin Noyola of the University of Texas at Arlington started listening for exomoons. That might sound unfeasible, but Jupiter's moon Io is known to trigger radio emissions as it moves through the planet's magnetic field, and Noyola hopes exomoons will do the same. A moon-induced

radio signal would be very weak by the time it reaches Earth, so Noyola is testing the idea by listening in to Epsilon Eridani b, which at 10 light years away is one of the closest known exoplanets. Just on the off chance, he is also eavesdropping on two other nearby star systems not yet known to contain exoplanets.

One way or another, the moon hunters are closing in. "My gut feeling is that we'll find an

"Exomoons can remain habitable far further out from their stars"

exomoon in the next few years," says Heller.

That's when the hard work will begin. To answer that all-important question about life, we need to know what the exomoons are like – do they have liquid water, or an atmosphere containing suggestive gases such as oxygen?

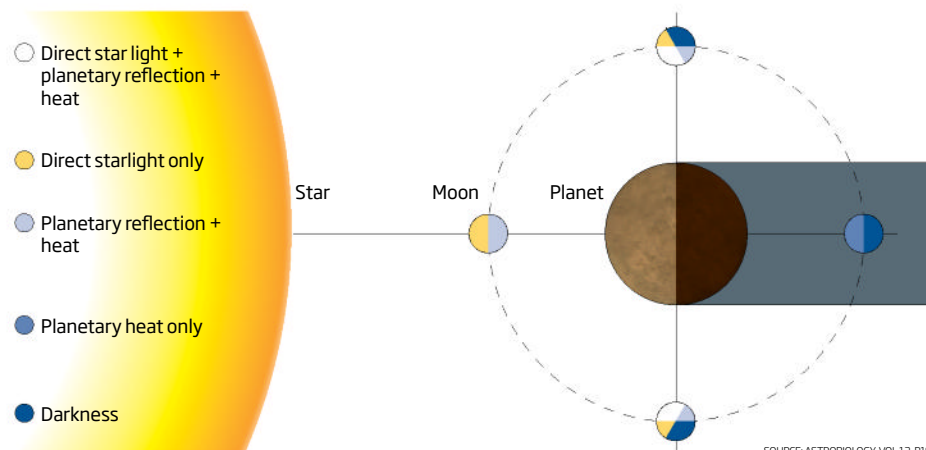
With exoplanets, that has proved tricky. The best way to sniff a distant planet's atmosphere is to look at the spectrum of starlight reflected from its surface, which will look different depending on what atmospheric gases are present to absorb various wavelengths. But for an exoplanet to be toasty enough to retain liquid water, it must be relatively close to its star, and that generally means the delicate signal of light reflected from the planet gets drowned out by the star itself.

Not so with exomoons, says Edwin Turner at Princeton University – for the simple reason that they can remain habitable further out. There has been a lot of talk in recent years about moons surrounding the gas giants in the outer reaches of our own solar system, such as Europa or Enceladus, being potential homes to life – albeit only primitive microbial life (see "Endomoons", far left). These bodies lie way outside our star's traditionally defined habitable zone, but in the neighbourhood of a giant planet additional sources of energy become available – light reflected from the planet, for example, as well as heat radiated as a young planet takes in gas and shrinks.

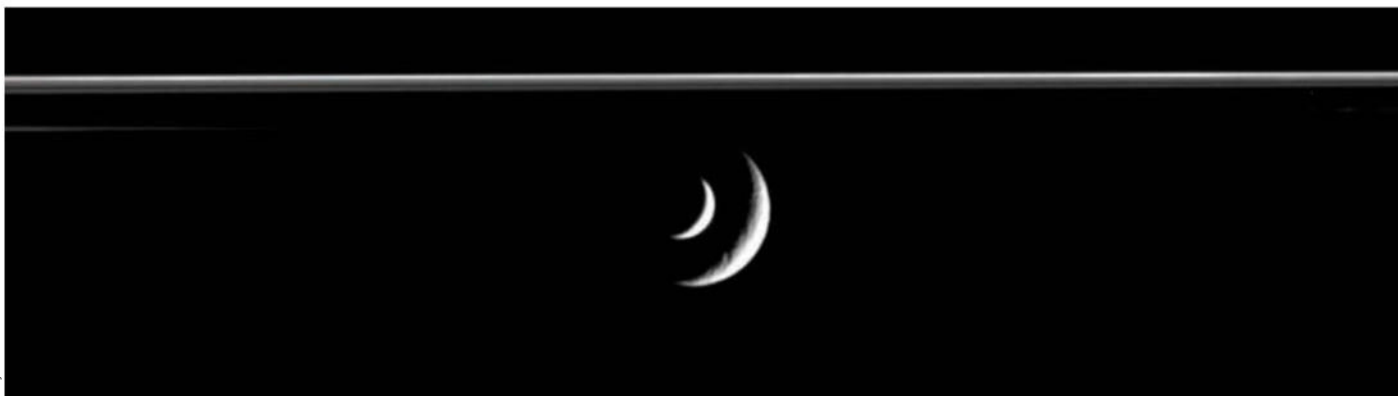
Then there is the effect known as tidal heating. In a system with more than one moon, varying gravitational pulls as the bodies orbit the central planet can stretch and squeeze a moon's interior, causing friction that can generate enormous internal heat. (Our moon's smaller pull doesn't generate much heat, but does create ocean tides.) Such effects could extend the region around a star in which liquid water can exist well beyond the habitable zone towards a "habitable edge" much further out.

By the light of an evening planet

Life on a moon would experience direct sunlight plus light reflected from its planet and heat emissions too – making for up to four phases of day and night



SOURCE: ASTROBIOLOGY, VOL. 13, P18



It's a fine balance – and any life on such a moon would have had to evolve in conditions of low light and high seismic activity (see “Plants of Pandora”, below). Then there are the strange phases of day and night that a body illuminated both directly by a star and indirectly by a planet would experience (see “By the light of an evening planet”, page 35).

Nevertheless, recent work by Turner and Vera Dobos, now at Konkoly Observatory in Hungary, shows how natural feedbacks could act as a thermostat on tidally heated moons, increasing the likelihood that they will have surface water. For example, if an ice-covered moon is close to its neighbouring planet, strong tidal forces might melt its ice, but the resulting water and slush would deform more

“A large, heated moon far enough from its star might even be visible directly”

easily and so generate less heat. That would prevent the world steadily getting hotter and burning off the water. The opposite effect would tend to keep ice – or indeed any surface material – near its melting temperature on moons further out from their planet. “This is an indication of why there might be a lot of liquid water in tidally heated moon systems,” says Turner.

A large, heated moon far enough away from its star's glare might even be visible

directly without any sophisticated detection algorithm. “You would point your telescope at it and take a picture of it at infrared wavelengths,” says Turner. “It's plain old straightforward astronomy.”

Even so, that would be right at the limit of existing infrared telescopes. The Spitzer Space Telescope would only see a nearby exomoon that's brutally hot – around 700 °C, in fact. But NASA's James Webb Space Telescope, due for launch in 2018, should be able to detect one at a relatively cool 27 °C and much further away from Earth.

There's even a chance the right infrared telescope might see signatures of atmospheric gases such as carbon dioxide and methane directly imprinted in the glow of a tidally heated planet, without being overwhelmed by light from the star. The fact the infrared light would be radiated from the surface of the moon, rather than being reflected starlight, changes the interpretation of what we see somewhat, says Turner. “But in general, the same principles would apply.”

All this means we could be characterising habitable moons far sooner than habitable planets, he says. “If you are talking about anything remotely Earth-like, then I think 10 years is very optimistic, and 20 years maybe. But moons we could be working on within a few years.”

Don't get your hopes of alien life up just yet, though, say both Heller and Turner. For a start, all ideas about exomoon habitability remain speculation until we have actually found some examples to test them on. And “until we find them we don't even know they are there. The solar system has lots of moons, but there's no guarantee that other systems do,” says Turner.

But assume our solar system is representative, it seems increasingly likely exomoons could be the first locations where we detect tantalising indications of life from afar. And that is a prospect far more exciting than any moon in the movies. ■

PLANTS OF PANDORA

Exomoons orbiting planets in other solar systems present us with many possible habitats – but not all are as lush as fictional creations.

RED DWARF MOON

Red dwarfs are the most abundant stars in our galaxy. Chances are these small, dim stars wouldn't illuminate lush green worlds. Photosynthetic life would have to draw light from as broad a range of the spectrum as possible, so is most likely to be black – as would life on a moon orbiting some distance from a sun-like star.

EARTH-LIKE MOON

A moon positioned further out than the stellar “habitable zone” – where temperatures are right for liquid water to exist – could still have Earth-like conditions. It would need to be large and get a tidal heating effect from its planet, and the mix of land and sea would be important. On a large watery moon, the oceans could be hundreds of kilometres deep and the pressures at depth too

severe for life to get started. Overall light levels would be lower, too.

HOT ROCKY EXOMOON

Far away from its parent star, this large moon gets most of its energy from tidal forces that drive plate tectonics. Depending on how much water it started out with, there might not be much there. Hyperthermophilic bacteria and archaea that thrive at temperatures above 80 °C on Earth could provide the best indication of what any life might look like.

THE EXTREME TIDAL MOON

If a moon were orbiting particularly close to a large planet, the tidal forces could be enormous. Here, as with Jupiter's Io, the rocky surface would bulge up and down by more than 100 metres, and the intense volcanic activity and searing heat would probably rule out life.

With thanks to Lewis Dartnell, research fellow in astrobiology at the University of Leicester, UK

Andy Ridgway is a science writer based in Bristol, UK

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Cuckoo in the nest

Why do so many animals care for the offspring of others, wonders **Lesley Evans Ogden**

AS PhD research projects go, Brian Wisenden's was enviable: wading knee-deep in shallow streams in the Costa Rican tropical dry forest, watching baby fish darting through the crystal clear waters. By recording their growth and numbers, he hoped to get an insight into their risks of being eaten.

Instead, he witnessed something odd. Many broods were increasing in numbers, not decreasing, as they were picked off by predators. In these groups, some of the fry were smaller than others, suggesting they weren't siblings. Wisenden had accidentally discovered that the fish, called convict cichlids, adopt each other's offspring. Why would they do that, he wondered?

Puzzling parenting

In the human realm, we think of adoption as a good and selfless act. But in nature, its presence is puzzling. Taking on the burden of rearing offspring to which they have no genetic link would seem to reduce an animal's chances of survival or at least provide no gain, meaning it couldn't have evolved via natural selection. Yet adoption is surprisingly common in the wild. As Wisenden and others

start to understand why, they are finding that animals adopt for all sorts of reasons. In some cases, the practice is far from benign, with disturbingly dark underpinnings. But in others it can have remarkable benefits, not just for adoptees but also for foster parents and even their natural offspring.

Nuclear families are a rarity in nature: many parents simply abandon their offspring to their fate. Where parenting does occur, it takes myriad forms. In some cases childcare falls on individuals who aren't the parents – a juvenile chimp might mind its younger siblings, for example, or animals that live in groups might share babysitting duties. But the individuals involved are usually kin, so the cost of caring is offset by the benefit of helping to pass on the genes they share. There can be other advantages too, such as safety in numbers. Adoption is another matter.

The classic example is the most easily understood. As any parent knows, raising kids is expensive and energetically exhausting – meaning there's a lot to be gained if you can get someone else to do the job for you. That's the strategy famously taken by brood parasites such as cuckoos and cowbirds. Here, adoption is by coercion and potential adopters





"Adoption can have disturbingly dark underpinnings"

evolve ways to try to avoid their fate. But if the host mounts careful surveillance, the parasite becomes ever more sneaky to outwit it. They are locked in an evolutionary arms race, fuelled by the fact that adoption is often very costly for those left holding the baby.

In the case of the common cuckoo, it means certain death for the host's offspring. Usually the "adoptee" hatches before its nest mates and tosses out the remaining eggs. Any resident chicks will suffer the same fate. "It's programmed to kill both," says Mark Hauber at Hunter College at the City University of New York.

By eliminating the competition, young cuckoos monopolise the entire food bonanza, wheedling host parents into servitude with relentless begging calls. Nestlings of the Horsfield's hawk cuckoo even have patches that look like mouths on the underside of their wings. They flash these to foster parents, ramping up the food supply by making it look like there are three mouths to feed, not one. Another species, the North American brown-headed cowbird, typically doesn't kill its nest mates but uses them to its advantage, intercepting more than its fair share of food brought by the harried parents. ➤

PHILIP HARRIS

Until recently, this adoption by deception was assumed to always come at a cost to the host, but it seems that in rare cases it may have benefits. What appears to matter is size. Unlike most brood parasite chicks, the young of the great spotted cuckoo are smaller than the offspring of its adoptive parent, the Eurasian carrion crow. Earlier this year it emerged that the crow chicks cash in on the enthusiastic begging of their adopted sibling to gain more food for less effort. The cuckoo chicks also expel a very stinky secretion that seems to deter predators, says Daniela Canestrari at the University of Oviedo in Spain, who was involved in the study. Whether the benefits outweigh the costs for crows over the long term is still uncertain, but ongoing work by Canestrari and colleagues suggests that they do, at least some of the time.

In brood parasites it's the parents that push their young into adoption, with the youngsters taking over the scam when they hatch. But adoption in the wild can also result from genuine cases of mistaken identity.

Take the eastern grey kangaroo. Between 2008 and 2013, Wendy King at the University of Queensland, Australia, and her colleagues followed the fates of 326 joeys in Wilson's Promontory National Park in Victoria and recorded 11 cases of pouch swapping. The circumstances underlying some of these adoptions aren't known, but four were straight swaps and another four occurred after a mother had lost her own joey. All of the adoptive mothers were already producing milk, and they usually adopted young of the same age and sex as their own, caring for them until they were weaned.

What's going on here? Before independence, baby grey kangaroos go through a period when they spend time inside and outside their



WENDY KING

"Discerning young may ditch their mothers to join a better-fed brood"

mother's pouch. Following out-of-pouch forays, mothers normally sniff their young before allowing them back in, but King's team suspect that during a kerfuffle they may skip the sniff test, allowing a vulnerable joey to quickly clamber in before fleeing from danger. Once inside the wrong pouch, the young may take on the mother's odour, making them smell confusingly like her own progeny.

So poor offspring recognition is the prime cause of "accidental" adoption in this species – and it's true of others, too. We take for granted

our ability to recognise individuals, but not all animals share this skill. They often use cues like sound, smell and sight, but they may only be able to discriminate between broad categories such as male or female, familiar or unfamiliar, and dominant versus subordinate. What's more, although many animal parents have evolved the ability to discern their own young from others', some aren't so good at it, paving the way for mistakes and cheating.

Disaffected youth

The consequences of adoption following mistaken identity can be dire. In the case of the grey kangaroos, the true offspring of adopting mothers were abandoned and died, unless a direct swap of joeys occurred. But

Brooding on it

The internet is a natural home for bizarre alliances and baby animals, so it's hardly surprising that stories of cross-species adoptions go viral. The unlikely couplings of gorilla and kitten, hippo and tortoise, elephant and sheep, snake and hamster, and lioness and baby oryx have all hit the big time. These animals tend to be either captive or domestic.

In the wild, instances of animals intentionally adopting young from another species are rare. Many of the reported cases involve birds. They include

Caspian terns adopting ring-billed gulls, white-tailed sea eagles raising common buzzards, and a female blackcap incubating and caring for a nest of yellowhammers abandoned by their parents.

An inkling of what might be going on here comes from the story of a king penguin that adopted a skua chick from under the noses of its parents. Skuas will eat penguin chicks and sometimes adults too, so this was risky. Nevertheless, the foster parent stood its ground against

attack from the chick's true parents.

The researchers who recorded the incident put it down to misplaced broodiness. Penguins need to maintain their parental drive during long absences to hunt for food, so have high levels of the "parenting hormone" prolactin. This might also be why penguins have been seen brooding pebbles, and why emperor penguins will kidnap chicks if their own brood fails. Misdirected broodiness might also explain some of the stranger interspecies adoptions you see online.



COURTESY OF BRIAN WISENDEN

For kangaroos adoption is a case of mistaken identity, but for convict cichlids it's more like kidnapping

some of nature's adoptions are actually driven by young looking for better prospects. In burrower bugs, for example, females lay a nest of eggs in close proximity to those of unrelated bugs. Mother burrower bugs tend their developing eggs before they hatch, then feed their offspring nutlets from weedy mint plants. Finding mint nutlets is a competitive business, so not every mother bug gets her fair share. And if the delivery rate isn't up to scratch, discerning young may ditch their mothers to join a better-fed brood.

That's similar to behaviour in several species of gull whose offspring, if poorly provisioned, may leave home in search of better parents. If they can inveigle their way into a nest where the chicks are smaller than they are, they gain an advantage when it comes to obtaining food.

Blue-footed booby chicks also have a tendency to put themselves up for adoption if their parents are poor providers. Being born the youngest to parents that struggle to feed their offspring puts a booby chick in danger of being bullied to death by its sibling. So, if the colony is dense and conditions in other nests are good, a last-hatched chick may take its chances with new parents. Yet life in the foster nest is tough because the chick is usually slightly smaller than the resident chicks. So the stakes for leaving home are high, but the risks of staying may be even higher.

Slim pickings aren't the only reason to seek new parents. Pierre Bize at the University of Bern in Switzerland and colleagues found that Alpine swifts born into nests heavily infested

with bloodsucking louse flies actively sought adoption. The more parasites were present, the more likely the chicks were to move to a new nest. By doing so they could nearly halve their parasite load, reducing the detrimental effects to their growth and development.

Adoption among geese is even more intriguing. Studying wild barnacle geese on Svalbard in the Norwegian Arctic, researchers at the University of Groningen in the Netherlands noticed widespread adoptions during the goslings' first week of life. At first they thought this was accidental. But observing the rate at which predators like Arctic foxes and gulls were picking off these feathered fuzzballs, they discovered that bigger families fared better than small ones. Back at the university, Jan Komdeur found

"Males have evolved the drive to adopt because it increases their sex appeal"

that greylag goose chicks seemed to be in charge of adoption decisions, preferring to throw in their lot with parents of a high social rank, which may also improve their chances of survival. "We think it is the chick deciding when to leave the family, and which family they want to join," he says. Their freedom to do so is aided by the fact that geese seem to find it hard to distinguish their own goslings before they are about nine days old.

While goslings may choose new parents,

other adoptees have little say. Perhaps the most devious examples of adoption involve parents "kidnapping" the young of others to act as a living shield for their own. This seems to underlie adoption in the convict cichlids studied by Wisenden, who is now at Minnesota State University in Moorhead. The fact that adoptees tend to be the smallest brood members led him to suspect that adoption wasn't simply a random process. Sure enough, experiments revealed that the true offspring were more likely to survive predation in broods that had extra, smaller fry than in broods with no adoptees. "[A predator] has got one shot, and it chooses the easy prey," says Wisenden. So by adopting offspring smaller than their own, parents are setting them up to be targets. "It's ruthless."

How convict cichlids acquire their sacrificial adoptees isn't clear. "Parents are always actively searching around and if they see babies, and they don't eat them, they will lure them into their brood," says Wisenden. Adoption is apparently so beneficial that almost everyone is doing it. Applying genetic paternity analysis to convict cichlids in Costa Rica, Wisenden recently found that nearly 80 per cent of broods contain adopted young.

Not all adoptive parents are dupes or villains, though. In some cases, taking care of someone else's kids can be a win-win scenario. Among tessellated darter fish, for example, males tend the young alone. A prospective father will set up his territory, clean the underside of a rock, wait for a female to lay her eggs there, and then fertilise them. "At a certain point that male, who is the father of the young, will leave," says Suzanne Alonzo of the University of California, Santa Cruz. Then, a smaller, unrelated male typically takes over the territory, picking up where the first male left off: cleaning the rock surface, aerating the eggs and defending them from other fish and predators. Females prefer males that are looking after healthy eggs so, despite his size, the adoptive dad may get lucky and fertilise some eggs of his own.

In the animal kingdom, a panoply of adoption stories illustrates that there is no single reason for adoptions to occur – and that there are still plenty of puzzles to ponder. But in the tessellated darter, at least, adoption makes perfect sense. "In this species, [it] is a sexually selected trait," says Alonzo. In other words, females love a doting dad, so males have evolved the drive to adopt because it increases their sex appeal. ■

Lesley Evans Ogden is a freelance writer, @ljevanso

Reality of the virtual world

Can knowledge find a happy home in VR, asks **Simon Ings**

THEY will tell you, the artists and engineers who work with this gear, that virtual realities are digital environmental simulations, accessed through wearable interfaces, and made realistic – or realistic enough – to steal us away from the real world.

I can attest to that. After several days sampling some of the latest virtual environments available in the UK, I found that reality righted itself rather slowly.

Along the way, however, I came across a question that seemed to get to the heart of things. It was posed by Peter Saville, prime mover of Manchester's uber-famous Factory Records, and physicist Brian Cox. They explained to an audience during Manchester's International Festival how they planned to fit the story of the universe on to sound stages better known for once having housed legendary soap *Coronation Street*.

Would *The Age of Starlight*, their planned immersive visualisation of the cosmos, give audiences an enriched conception of reality, or would people walk home feeling like aliens, just arrived from another planet?

Cox enthused about the project's educational potential. Instead of reading about woolly mammoths, he said, we will be able to "experience" them. Instead of reading about a mammoth, trying to imagine it, and testing that imagined thing against what you already know of the world, you will be expected to accept the sensory experience offered by whoever controls the kit. "We will be able to inject people with complex thoughts in a way that's easier for them to



PETER EARL/MCCOLLOUGH/THE NEW YORK TIMES/REDUX/EVEVINE

understand!" Cox exclaimed. So, of course, will everyone else.

Institutions of learning, then, had best associate their virtual reality experiments with the most trustworthy figure they can find, such as David Attenborough. His *First Life* is the London Natural History Museum's joyride through perilous Cambrian shallows, built on the most recent research.

"When the film starts, try to keep your arms to yourselves," begged the young chap handing out headsets at the press launch, for all the world as though this were 1895 and we were all about

"Instead of reading about woolly mammoths, said Brian Cox, we will be able to 'experience' them"

to run screaming from Louis Lumière's *Arrival of a Train*. The animator, given free rein, renders tiny trilobites on human scale. This is a good decision – we want to see these things, after all. But such messing around with scale inevitably means that when something truly monstrous appears, we are not as awed as we perhaps ought to be.

VR sets awkward challenges like this. From a narrative perspective, it is a big, exciting step away from film. Camera techniques like zooming and tracking ape the way the eye works; with VR, it is up to us what we focus on and follow. Manipulations have a dreamlike effect. We do not zoom in; we shrink. We do not pan; we fly.

Meanwhile, virtual reality is

Nowhere to turn: feeling present in virtual reality is still far from easy

still struggling to do things everyone assumes it can do already. Accurately reading a user's movements, in particular, is a serious headache. This may explain the excitement about the two-person game *Taphobos*, which solves the problem by severely limiting the player's movements. *Taphobos*, a play on the Greek words for "tomb" and "fear", traps you in a real coffin. With oxygen running out, the entombed player, equipped with an Oculus Rift headset, must guide their partner to the burial site over a radio link, using clues dotted around the coffin.

"This combination," say the

makers, master's students in computing at the University of Lincoln, UK, "allows you to experience what it would be like if you were buried alive with just a phone call to the outside world." Really? Then why bother? By the time you have addressed virtual reality's many limitations, you can end up with something a lot like, well, reality.

London's theatre-makers know this. At first, immersive entertainments such as *Faust* (2006) and *The Masque of the Red Death* (2007), pioneered by the theatre company Punchdrunk,

"VR may be able to present the world in a way that would be inaccessible to our unaugmented senses"

looked like mere novelties. Now they are captivating bigger audiences than ever.

Traditional theatregoers may grow weary of running confused across gargantuan factories and warehouses, trying to find where the action is, but for gamers such bafflement is a way of life, and to play scenarios out in the real world is refreshing.

Until 27 September, London-based Secret Cinema offers a similar sort of immersion: inviting you to come battle the evil Empire through several meticulously realised sets as a warm-up to a screening of *The Empire Strikes Back*. It's all played at a gentle, playful pace: something between a theatrical experience and a club night.

Right or wrong, VR promises to outdo these entertainments. It's supposed to be better, more engaging than even the most carefully tailored reality. That's a very big claim indeed.

More likely, VR may be able to present the world in a way that would otherwise be inaccessible to our unaugmented senses. The first tentative steps in this direction were apparent at this year's Develop games conference in Brighton, where the Wellcome

Trust and Epic Games announced the winner of their first Big Data Challenge. Launched in March, the competition asked whether game designers could help scientists to better visualise incomprehensibly large data sets.

Among the front runners was Hammerhead, a team taking on the enormous task of designing a decent genomics browser. They have barely changed in a decade. Once they held barely a dozen data fields, now they need hundreds since studying the behaviour of different genes under different conditions is a multidimensional nightmare. Martin Hemberg of the Sanger Institute, who set the challenge, explained: "Genomics is very data-intensive. Trying to integrate all this and make sense is a huge challenge. We need better visualisation tools."

Hammerhead's proposal promises something close to SF writer William Gibson's original conception of cyberspace: a truly navigable and manipulable environment made of pure information. Not surprisingly, it will take more than the challenge's modest \$20,000 to realise such a vision.

Instead, the prize was handed to two London studios, Lumacode and Masters of Pie, who collaborated on a tool that is already proving itself as it takes the 14,500 family health records in the Avon Longitudinal Study of Parents and Children, and spits them out in real time so researchers can follow their hunches. It even boasts privacy tools to facilitate the work of hundreds of researchers worldwide.

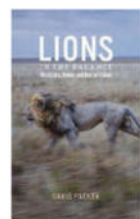
On current evidence, today's VR is going to change everything by just a little bit. It will disconcert us in small ways. It will not give us everything we want. But reality doesn't either, come to that. We can afford to be patient. ■

Simon Ings was one of the judges at Develop in Brighton, UK

Killing the killers

A tough, innovative strategy turns lion conservation on its head, finds **Iris Barbier**

Lions in the Balance: Man-eaters, manes, and men with guns by Craig Packer, University of Chicago Press, \$35



THE Disney classic *The Lion King* paints a rosy picture of lion behaviour. Unfortunately, this romanticised image of the ruler

of the Serengeti is so pervasive even activists can go soft on lions.

Locals who put up with them daily tell a different story. They speak of people-eating, cattle-killing beasts that carry out infanticide and are worthy of being hunted to extinction, and of gaining manhood by so doing.

In *Lions in the Balance*, ecologist Craig Packer writes: "Lions need trophy-hunting just as much as trophy-hunting needs lions." His plan: kill only male lions over the age of 6, so cubs aren't killed by a lion mating with their mother who seeks to safeguard his own progeny. This is a fresh approach to conservation, where

Can regulated hunting offer the best route to lion conservation?

hunting is essential to survival. It might just change the lion behaviour he describes in this sequel to his classic, *Into Africa*.

As he exposes corruption in Tanzania's hunting industry and tries to get his plan adopted, diary entries show Packer and his colleagues taking on locals, hunters and megalomaniac politicians in a struggle to balance human needs, a lucrative hunting trade and true Serengeti science.

His brave accounts of blackmail and death threats are alarming. At one point, the book describes a desperate strategy to protect the ecosystem while pacifying the crooked policy-makers. Packer aimed to identify lions' age by the fullness of their manes and by ear markings, but politicians refused, saying it would restrict the hunt.

The book makes compelling reading as we journey through pioneering science, dodging the influential government fat cats on the way. Packer is completely candid about the "ethics" of those instrumental in the future of the King of the Beasts. Let's hope someone will listen. ■

Iris Barbier is a writer based in the UK



DAVID CHANCELLOR/INSTITUTE

Science takes a vacation

Adam Roberts rounds up fictions and fables fit for the holidays

TIME and space, death and hope: that about covers it, surely? If you're looking for a little light reading for the summer, the best science writing and science fiction are – to coin a phrase – boldly going where none have yet gone.

Published last year and nominated for the Hugo and Nebula awards, Cixin Liu's *The Three-Body Problem* (Tor), translated by Ken Liu, is a mix of satisfying hard-SF – those au fait with orbital mechanics won't need to have the titular problem explained – and a fascinating glimpse inside modern China. But it is a rare novelist who can combine literary skill with properly researched hard science, and in this respect, Kim Stanley Robinson's *Aurora* (Orbit) is streets ahead of the competition. A starship is 160 years into its voyage: two huge wheels, spun to imitate gravity, contain 12 inhabited ecosystems, from tropical forest to tundra, each with their own human population, maximised for biological diversity. We follow the ship though decades as Robinson brilliantly dramatises the action of entropy in complex systems. Crops fail; kilometre-long artificial lights die, leaving whole biomes in the freezing dark; lakes wash away their beds and start to corrode the fabric of the ship. The crew make repairs, their vessel becoming ever more of a botched job, and increasingly prone to further breakdowns. The technical challenges superbly illuminate the human dramas, and vice

Death becomes us: mortality is a popular literary theme this year

versa. This is science fiction at its very best.

Australian author James Bradley's *Clade* (Penguin) is a beautifully written meditation on climate collapse, concentrating on three generations of an Australian family. Bradley skilfully evokes the particularity of lived experience, and the novel is full of vivid little moments, although its real triumph is in setting these in their larger context: a world

"We follow the ship through decades. Crops fail; lights die, leaving whole biomes in the freezing dark"

wrecked by storms and floods, changes in vegetation and the collapse of bird and bee populations. The main task climate science faces is getting people to understand how serious the situation is without tipping them over into nihilism. Bradley's short, intense novel is as much a hymn to hope as it is a warning.

S.N.U.F.F.: A Utopia (Gollancz) is the latest example of Victor Pelevin's unique blend of satire

and SF extrapolation. The high-tech city of Byzantium floats in the sky over Urkania, its citizens entertained by specialist porn and staged wars. Down below, the Orks live primitive, exploited but more authentic lives. The satirical contrast between luxury above and poverty below is not subtle. This is an angry, funny novel, crammed with puns and wordplay. (Translator Andrew Bromfield does a bang-up job of replicating these in English.) "Byz" is a distorting mirror version of the decadent West, a realm of atrophied liberalism and too much wealth. The age of consent is 46. People have sex with full-sized robot dolls, which can be any age you want. Pelevin bounces about, energetically and crudely, and fashions a gonzo delight.

From dying societies to dying individuals. Raymond Tallis's latest book, *The Black Mirror: Fragments of an obituary for life* (Atlantic Books), opens starkly: "death is nothing" and indeed "less than nothing, an omni-ravenous zero". "Those whom we call 'the dead' neither

A chance to reflect: several stories consider how we handle nature

enjoy their peace nor endure their loss." Accordingly, Tallis writes his own obituary looking back rather than forward, going over the life previously lived by the corpse once known as "RT". The result is a book full of striking, thoughtful insight, defamiliarising the everyday things we all take for granted. Its prose-poetry will either delight or infuriate, and reveals an author unafraid of ending up in *Private Eye*'s Pseud's Corner: "unimpoorished psychogeography", "a maculate pattern of warmth and coolths" and "the merely utile" are a taste of what to expect. Tallis doesn't simply stroll, he "undertakes set-piece ambulations". Working out at the gym "instantiates the essence of the burdensome". A comfy chair is "an ergonomically friendly receptacle". In an age when books of popular science tend to adopt a chatty style



ALEJANDRO AYALA/REX SHUTTERSTOCK

BRUNO BARBEY/MAGNUM PHOTOS

Six to savour



halfway to dumbing down, Tallis's commitment to his rich, difficult and estranging idiom is admirable. Or commercially suicidal. Conceivably both.

A different approach to death informs Chris Adrian and Eli Horowitz's witty *The New World* (Farrar, Straus and Giroux). When Jim dies suddenly, his widow Jane is startled to discover that he signed his head over to a cryonics company called Polaris. Angry at what she sees as a desecration, she threatens litigation and tries to retrieve the head. Meanwhile, in what may be a computer simulation, post-mortem Jim is told he must shed all of his memories and loves in order to move on to his "debut", the passage of his connectome ("the totality of his neurological connections") into endless life. Jim finds this hard to do, and there is warmth and poignancy in the dual narratives of his and Jane's rather different struggles to hold on to something that death

has violated. At the heart of this novel is the portrait of a marriage, flawed but also loving and enduring. It is movingly done.

Kate Atkinson's new novel *A God in Ruins* (Doubleday) really

"Tallis's commitment to his rich, difficult idiom is admirable. Or commercially suicidal. Conceivably both"

needs to be read as a companion-piece to her last, *Life After Life* (2013). The two together may well be the most eloquent writing about death I have ever read. In *Life After Life* we follow Ursula Todd as she is born, dies, is born again, and dies again, through early flu, an accident, and so on, over and over, each time lasting a little longer. Slowly, a sense of her repeating existence seeps into her mind, and she tries to direct events with the aim of saving the life of her beloved brother, Teddy, who is shot down over Berlin in a second world war bombing raid.

A God in Ruins tells the story from Teddy's point of view: an ordinary, linear life of small satisfactions and many trivial disappointments, from childhood through war and finally into old age and his death in a care home. The narrative, like that of Kurt Vonnegut's satirical novel *Slaughterhouse-Five* (1969), jumps restlessly from future to past, creating a deliberate, powerful flattening of the events of Teddy's life. It all comes to a piercing conclusion as the various foci resolve into two moments: the Berlin air raid and Teddy's impending death.

Emotionally truer than the studied pretentiousness of Tallis, more nuanced than the cartoon exaggerations of Adrian and Horowitz, it is extraordinary writing. ■

Adam Roberts is a science fiction writer and professor at Royal Holloway, University of London

The 28 stories in China Miéville's *Three Moments of an Explosion* (Macmillan) are familiarly strange, full of eloquent monstrosity. A burning stag runs through a city, icebergs float over towns. Miéville's vision has a fragmentary force, and this mosaic text does it proud.

Darran Anderson's *Imaginary Cities* (Influx Press) is a big, bustling book that looks at real cities through the prism of imaginary ones, from city planning to science fiction and everything in between. Anderson's nimble study is never less than stimulating.

Joshua Cohen's *Book of Numbers* (Harvill Secker) may be too tricky for some. It is also frequently amazing, the first work of fiction to engage fully with the internet and its influence on modern living.

Claire North's *The First Fifteen Lives of Harry August* (Orbit) recently won the John Campbell Memorial Award. Harry lives his life over and over, always the same - until he discovers others like him. By talking to those younger or older he can pass messages along to the future or the past. North builds her clever conceit into an emotionally satisfying novel.

John Higgs wrote well-received biographies of Timothy Leary and The KLF. In *Stranger Than We Can Imagine: Making sense of the twentieth century* (Weidenfeld & Nicolson), he broadens his intellectual reach to encompass modernism, situationism, chaos theory, indeterminacy and almost every other byway of that epoch. Higgs's plate-spinning act is a fine example of learning worn lightly.

Finally, Brian Dillon's *The Great Explosion: Gunpowder, the great war, and a disaster on the Kent marshes* (Penguin) tells the story of the explosion of the Faversham Gunpowder Works in 1916: safety was compromised as a result of pressure to boost production, and 200 workers were killed in a blast that shook houses as far away as Norwich. Dillon situates this story in a wider account of the Kentish landscape. ■

Cancer Prevention Fellowship Program



The National Cancer Institute (NCI) Cancer Prevention Fellowship Program (CPFP) is now accepting applications for Cancer Prevention Fellows. This is a unique postdoctoral training opportunity for scientists and clinicians in the fields of cancer prevention and control.

As part of the program, fellows receive:

- The opportunity to obtain an M.P.H. degree at an accredited university during the first year, followed by mentored research with investigators at the NCI. Research opportunities exist across the spectrum of cancer prevention research, including: epidemiology, biostatistics, clinical services, laboratory, social and behavioral sciences and engineering.
- Competitive stipends, paid health insurance, reimbursement for moving expenses, and a travel allowance to attend scholarly meetings or training.

The typical duration in the CPFP is 4 years (year 1: master's degree; years 2-4: NCI Summer Curriculum in Cancer Prevention and mentored research).

Applicants should meet the following eligibility criteria:

- Possess an M.D., Ph.D., J.D., or other doctoral degree in a related discipline or must be enrolled in an accredited doctoral degree program and fulfill all degree requirements by June 2016.
- Be a citizen or permanent resident of the United States at the time of application.
- Have no more than five years relevant postdoctoral experience.

The application deadline is August 25, 2015. To be considered, individuals must submit application via the CPFP website (<https://cpfp.cancer.gov/>)

To learn more about eligibility requirements and to apply, please visit our website

<https://cpfp.cancer.gov/>

If you have specific questions, please contact cpfpcoordinator@mail.nih.gov



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SANFORD RESEARCH

Sanford Research, located in Sioux Falls, South Dakota, is currently seeking a full-time **Postdoctoral Fellow** for the Chandrasekar Lab.

The Chandrasekar lab investigates the role of actin associated proteins in cell and organ function. We study membrane trafficking and endocytic mechanisms in organ specific cell types and how actin cytoskeleton regulates this process. We use cell culture methods along with advanced imaging techniques to address some fundamental cell biology questions and extend these findings to organ function in mouse models.

We are seeking highly motivated individuals with excellent problem solving skills. The ideal candidate will have a Ph.D. in molecular cell biology or related field, with some experience in microscopy/imaging techniques. Training in mouse models and mouse genetics will be provided. The position should be of interest to young scientists who want to apply cutting edge microscopy techniques and mouse genetics to study basic cell and organ biology and relate the findings to human diseases.

To view a full job description and to apply, visit careers.sanfordhealth.org and reference job #231067.

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Send curriculum vitae and names and addresses of three references to Dr. Jonathan H. Jaggar, Maury Bronstein Endowed Professor of Physiology, Department of Physiology, University of Tennessee Health Science Center, 894 Union Avenue, Memphis, TN 38163, USA.

Email to: jjaggar@uthsc.edu.
<http://physio1.uthsc.edu/~jaggarj/index.php>

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Call for Applications Chair, Department of Medical Biophysics

The Schulich School of Medicine & Dentistry, at Western University, is inviting applications for the position of Chair in the Department of Medical Biophysics.

As Canada's first Department of Biophysics, the Department has grown to become one of Canada's leading centres for medical biophysics research with approximately 20 primary faculty members and over 70 actively collaborating cross appointed faculty leading internationally recognized research programs in medical imaging, microcirculation, computational modelling, biomechanics, and cancer. The department is the academic home to both undergraduate and graduate programs, including CAMPEP accreditation. It draws on a rich city-wide infrastructure incorporating two research Institutes, three hospitals, and five University Faculties. Research programs benefit from close collaborations between clinical and basic science faculty, with unique training programs in diverse fields.

The successful candidate should have a demonstrated track record of leadership and research and teaching excellence with a proven reputation for effective interpersonal and administrative skills. The new Chair will facilitate collaboration and be expected to support the research, educational and interdisciplinary initiatives of the Department. The successful candidate will build on the strength and forward momentum of the Department's graduate and undergraduate programs and promote the development of new initiatives in research, scholarship and education. He or she must have a PhD, MD, DDS or equivalent, and will receive a tenured academic appointment at the level of Associate or full Professor. Candidates with a research program complementing existing research strengths are particularly encouraged to apply. The position of Chair is for a five-year term, renewable.

Western University is located in London, Ontario, with a metropolitan census of 530,000. As Canada's 11th largest city, London boasts an extensive educational and health care community. With full time enrollment of 32,000, Western graduates students from a range of academic and professional programs. Further information about the Schulich School of Medicine & Dentistry and Western University can be found at www.schulich.uwo.ca, and <http://www.uwo.ca>. Western's Recruitment & Retention Office is available to assist in the transition of successful applications and their families. Details about the Department of Medical Biophysics can be found at <http://www.schulich.uwo.ca/biophysics/>.

Interested candidates should submit a CV outlining their research, teaching, and administrative experience and interests, including future directions, together with the names and addresses of three referees to:

Dr. Michael Strong, Dean
Schulich School of Medicine & Dentistry
Room 3701A, Clinical Skills Building
Western University
London, Ontario N6A 5C1
FAX: (519) 850-2357
selection.committee@schulich.uwo.ca

Please ensure that the form available at <http://www.uwo.ca/facultyrelations/faculty/Application-FullTime-Faculty-Position-Form.pdf> is completed and included in your application submission.

Applications will be accepted until the position is filled.
Review of applicants will begin after September 30, 2015.

Positions are subject to budget approval. Applicants should have fluent written and oral communication skills in English. All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority. Western University is committed to employment equity and diversity in the workplace and welcomes applications from all qualified individuals, including women and men, members of visible minorities, aboriginal persons, persons with disabilities, and persons of any sexual orientation or gender identity.

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Scientists in any field who have a doctorate in the area of the proposed project (by December 2014) and at least two published articles or monographs are eligible to apply for a Radcliffe Institute fellowship. The stipend amount of \$75,000 is meant to complement sabbatical leave salaries of faculty members. Residence in the Boston area and participation in the Institute community are required during the fellowship year.

Applications for 2016-2017 are due by October 15, 2015.

For more information, please visit www.radcliffe.harvard.edu or email sciencefellowships@radcliffe.harvard.edu.

Biodomain Researcher



Purpose

Candidates are sought to fill a scientist position in Shell's Biofuels Research and Development program. The program is focused on delivering Next Generation Biofuels into the market, primarily from ligno-cellulosic feedstocks, by both biological and thermochemical routes.

Role Accountabilities

The role will be based in Shell's Projects & Technology Group, located in the Shell Technology Center, Houston, Texas. The successful candidate will work within Shell's in-house Microbial Biofuels team, scaling-up Shell's proprietary ligno-cellulosic biofuel process from the bench to production scale. The challenges in such a process range from soil carbon and ecosystem services analysis, through enzyme hydrolysis, solid and liquid phase fermentation, to molecular microbiological transformations.

Potential candidates will be engaged in a range of activities such as: ecosystem service modelling, molecular transformation, microbial pathway evolution, enzyme hydrolysis, novel fermentation, and organism research.

Responsibilities will include: design and implementation of experimental programs aimed at producing commercially viable biofuels from micro-organisms, taking into account a wide range of contributory factors; and identifying opportunities and engaging with the development of commercial plans.

Candidates are expected to have excellent intellectual and analytical ability, the enthusiasm to progress their insights, strong teamwork and leadership skills, as well as the ability to broaden outside of their area of expertise. The successful candidate will be expected to work with Shell engineers globally, as well as with external partners.

Required Qualifications/Skills

Ideally, the successful candidate will have a PhD (or be in their final year/ write-up of a PhD) in one of the following areas, or a related field:

- Microbiology
- Biochemistry
- Environmental Microbiology

They will have demonstrated a willingness to learn and apply cross-discipline approaches to solving problems, and be happy working in a tight-knit team.

Experience in one or more of the following areas would be a distinct advantage:

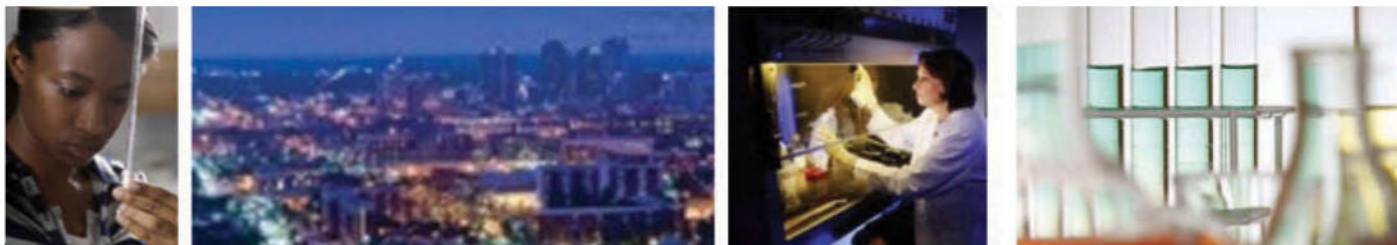
- Soil carbon pathways and sequestration
- Metabolic pathway improvement via transformation
- Enzyme hydrolysis
- Solid or liquid fermentation (batch or continuous flow at pilot scale)

Application Requirements

- To be eligible for Graduate full-time opportunities, you should be in your final year of study or have less than three years of work experience.
- You must have a minimum Cumulative GPA (CGPA) of 3.20.
- Candidates for regular U.S. positions must be a U.S. citizen or national, an alien admitted as permanent resident, refugee, asylee, temporary resident, or an individual who possesses valid work authorization. Individuals with temporary visas (H-1, H-2, J-1, F-1, etc.) or who require sponsorship for work authorization now or in the future are not eligible for hire.

How to Apply

- In order to be considered for this position you must apply online at www.shell.us/careers.
- In the "Students and Graduates" section, click on "Shell Recruitment Day" and then create an account. When entering your contact details, select "Other" in response to "Where you found out about this Shell opportunity," click "Next" and then type in "Biodomain Researcher."
- We require a completed application, an updated copy of your résumé and an unofficial copy of your transcripts / grade report prior to be considered for an interview.



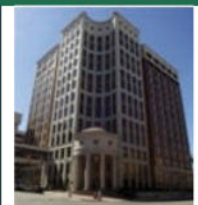
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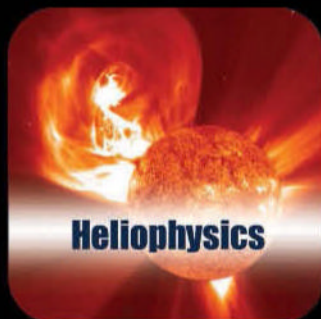
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Postdoctoral fellowship on an NIH Institutional Training Grant entitled *Botanical Approaches to Combat Metabolic Syndrome*, seeks MD or PhD with strong scientific credentials and interest in animal or human metabolic research using botanicals. Fellowship provides up to three years of funding for training in lab skills and coursework necessary for establishing an independent research career. Must be a US citizen or green card holder.

This training program is sponsored by the National Center for Complementary and Integrative Health (formerly NCCAM) and is located within the Botanical Research Center (BRC) on the campus of Pennington Biomedical Research Center in Baton Rouge, Louisiana.

T32 postdocs will work toward enhancing research interactions between botanical characterization and molecular/genetic/physiologic approaches in both the basic science and clinical research areas. Trainees working in the laboratories of our basic and clinical scientists will benefit from collaborative research with botanical scientists. Learning about multiple areas of metabolic research and how botanicals interact and influence metabolic and cellular pathways will likely promote creativity and inspire trainees to transcend the boundaries that limit current research. We want our trainees to gain exposure to at least two specialty areas (e.g., genetics of metabolic syndrome, molecular regulation of insulin action, biochemical botanical characterization, botanical therapeutics) as we anticipate this will encourage future interdisciplinary research efforts needed to understand this complex and challenging syndrome.

** NIH requires applicants to be US citizens or have resident alien status for this training program.*

For more information please visit:
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You must have earned a PhD or EdD in physics, science education, or a related field by the date of appointment and be eligible to teach physics courses. You will be given preference if you have completed a dissertation in qualitative or quantitative physics or science education research. The successful candidate will demonstrate outstanding teaching and mentoring skills, excellent writing skills, and the ability to work collaboratively with diverse students, researchers, faculty, and staff.

The initial appointment will be for one year with a possible second year term appointment contingent upon performance and availability of funding.

The PER group at KSU has two faculty members, two postdocs, five graduate students, and three undergraduates, as well as faculty affiliates in physics and other STEM fields. The Physics Department is a friendly and supportive environment for PERers. Manhattan is a vibrant and affordable community situated in the beautiful Flint Hills region of Kansas.

Candidates should submit a packet including: a letter of application; vita including a list of publications; and a research statement describing the candidate's relevant background, interests in physics or science education research, and the relation of the position to the candidate's long-term goals. Send your packet to the PER group's search email, persearch@phys.ksu.edu, in PDF format. You should also arrange for three letters of reference to be sent to the above address. If you have questions about the position, the research group, or the institution, contact Dr. Ellie Sayre at esayre@ksu.edu.

Screening of applications will begin August 15, 2015 and continue until position is filled.

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EDITOR'S PICK



Childbirth in a calm, quiet place

From Alisoun Gardner-Medwin

Reading your interview with Michel Odent about clinical settings repressing women's capacity to give birth (4 July, p 26), I recalled the wise midwives of the Princess Mary Maternity Hospital in Newcastle upon Tyne.

At midnight, when I was in early labour, I was invited to rest in a homely bedroom. The low bed, which had a white pillow and sheet and a scarlet tartan coverlet, was illuminated by a lamp on a bedside table. There was an electric button at the edge of the table. The midwife asked me whether I would prefer the lamp on or off and I said, "Off, please." In the darkness, I saw a line of red lights along the skirting board, enough to enable a midwife to walk safely, but not enough to disturb me. I felt so safe that I went to sleep.

A few hours later, she took me to the delivery room, which was lit but the lights didn't shine in my eyes. I felt relaxed and confident, and the birth was quick and easy.

That was 50 years ago, but women in early labour always need somewhere to wait, and they can still be given peace, darkness, safety and surroundings that are homely rather than clinical.
Heddon on the Wall, Northumberland, UK

To read more letters, visit newscientist.com/letters

Climate cognition constraint clamour

From Tony Castaldo

Of the 33 psychological "dragons" that Robert Gifford says stop us countering climate change (11 July, p 28), I fail to see why number 13, Technosolution, is to be slain at all. Indeed, I believe our only chance of mitigating global warming is a technosolution.

Many of the changes that people call for are simply impossible to implement. Most are worthless without a strong world government and, worse still, they would crash the global economy if they were to be implemented. People are far too stubbornly resistant to change to do anything significant about global warming until they are personally suffering hardships and the death of loved ones – at which point it will be far too late.

Encouraging climate positive behaviours such as bike riding makes a negligible difference. What's needed is some cheap solar-powered device that can produce neat carbon pellets by the megaton to be promptly sunk to the bottom of the Pacific.

Technology doesn't require majority agreement. It can be deployed unilaterally by a few countries that agree.

San Antonio, Texas, US

From Howard Barnes

Surely that headline should be "33 excuses for not thinking clearly about climate change"?
Kempston, Bedfordshire, UK

From Steve White

Reading Paul Younger's article cheering on the UK's fracking industry (11 July, p 24), I wondered which of the "33 reasons we can't think clearly about climate change" (p 28) clouded his judgement. It is generally accepted that we need to leave most of the known fossil fuel reserves in the ground. So does it not seem perverse to begin

investing heavily in a new source of fossil fuel? Turning around Younger's final paragraph: in the short term isn't it better to import more of our gas from countries such as Norway and the Netherlands, which are noted for better due process than we enjoy in the UK?

No doubt confirmation bias would allow him to pigeonhole Robert Gifford's article as "pseudoscientific gobbledygook".
Great Edstone, North Yorkshire, UK

From Harold Caplan

I am convinced there are many more than 33 reasons why we fail to act on climate change. For example: the world's sovereign states seem to have agreed that the impact of military activities on climate should never become a topic for high-level discussions. Future generations may come to see this as the largest unexplained crime against humanity in the history of our species.

Even if the next crucial climate conference in Paris in December yields the lasting results we hope for – unlike the 2009 conference in Copenhagen – it is civilians alone who will shoulder the consequences.

Sunbury-on-Thames, Surrey, UK

The editor writes:

■ There are many such further "structural" barriers to action on climate change, but Robert Gifford's research focuses solely on the psychological reasons for us not acting.

Official drugs boringly on tap

From Michael Bell

David Nutt protests proposals to outlaw "psychoactive" drugs (13 June, p 24). There are indeed many problems with these proposals: one is how to define "psychoactive". Establishing that requires testing, which would now be illegal. It is too easy for

governments to outlaw chemicals that have no conceivable psychoactive properties. We need a policy that takes the money, the mystique and the thrill out of recreational drugs.

I suggest that the NHS should provide doses of recreational drugs with known toxicology for a nominal price, say £5 a shot, in plain packaging, no more than two shots at a time. The real criminals couldn't make money if we did this. But the "hang 'em and flog 'em" party would cancel out the rational policy-makers.

Newcastle upon Tyne, UK

New drugs on your kitchen table

From David Muir

Jon White writes: "synthesis machines will eventually mean anyone, scientist or layperson, can make a new molecule" (11 July, p 34). On the same day, I read in a national newspaper of users of "legal highs" being admitted to hospital with car-crash-like internal injuries.

Just as 3D printers may spawn illegal weapons, I fear such a synthesis machine will give drug makers a lucrative new avenue. History indeed "shows us that putting technology into the hands of non-experts can have tremendous impacts" – but not always for society's benefit.

Edinburgh, UK

What's bad for some is not for all

From Meghann Mears

Many of the articles in your series about guilty pleasures (30 May, p 30) are based on a fallacy. Most of the studies cited are epidemiological, dealing with statistics at the population level. Unfortunately, population statistics can only inform population-level initiatives:

f “There’s no one right way for everyone, and no one should be shamed for doing what’s right for them.”

Sarabeth Burns intervenes in a row on Facebook about advice on vaginal and caesarean birth (25 July, p 5)

individual circumstances need to be considered when making individual recommendations.

As an example, there is some evidence that extreme endurance exercise can increase morbidity and mortality, and exercise can harm undernourished people and those with injuries. Advice based on population statistics that average over these cases may harm the majority for whom, in general, exercise is beneficial. *Chesterfield, Derbyshire, UK*

Heaven on Earth and the Coal Board

From Charles Jencks

Sumit Paul-Choudhury is right to emphasise the way architecture and landscape have long celebrated the cosmos and are doing so again today (4 July, p 44). There is one point I would like to clear up. He mentions the “yellow gorse creeping over the spiralling mounds” of a former Scottish Coal site I designed, which is “succumbing to entropy after

its funding ran out”. It is called The Scottish World Project and its present state is the result of Scottish Coal going bust. The Scottish people were furious over the way £250 million of restoration bonds disappeared from moribund coal sites, which remain eyesores.

My design saved Scottish Coal money, because instead of them having to restore the land back to flatness, I incorporated their existing slag-heaps into artful mounds. Let us hope somebody will make good on the funding promises in future. *Holywood, Dumfries, UK*

Climate change and an expanding Earth

From David Sugerman

Michael Le Page reports updated calculations of sea level rises due to climate change (13 June, p 8). Is it possible that these omit the thermal expansion of Earth? The very large size of Earth multiplied by small coefficients of expansion

and relatively small temperature rises could significantly increase surface area. Would this reduce sea level rise?

Kangaroo Point, New South Wales, Australia

The editor writes:

■ It takes a very long time for heat to penetrate to any depth into Earth’s crust: this factor will be relatively insignificant over the next few centuries.

Sex, lies and gaps in surveys

From Richard Parkins

You highlight a claim that the average number of sexual partners in a lifetime is 12 for men but only 8 for women (27 June, p 34). As others point out (Letters, 18 July), this is impossible if we assume the great majority of couplings are of two people of different sexes; and it is a bit unrealistic to expect people to necessarily tell the truth about such matters. The figures may

simply reflect a tendency among women to be more reticent about their numbers of sexual partners.

It is also possible to account for surveys producing these false results if men count women who they pay for sex as “partners”, and these women are either under-represented in surveys or do not report the men.

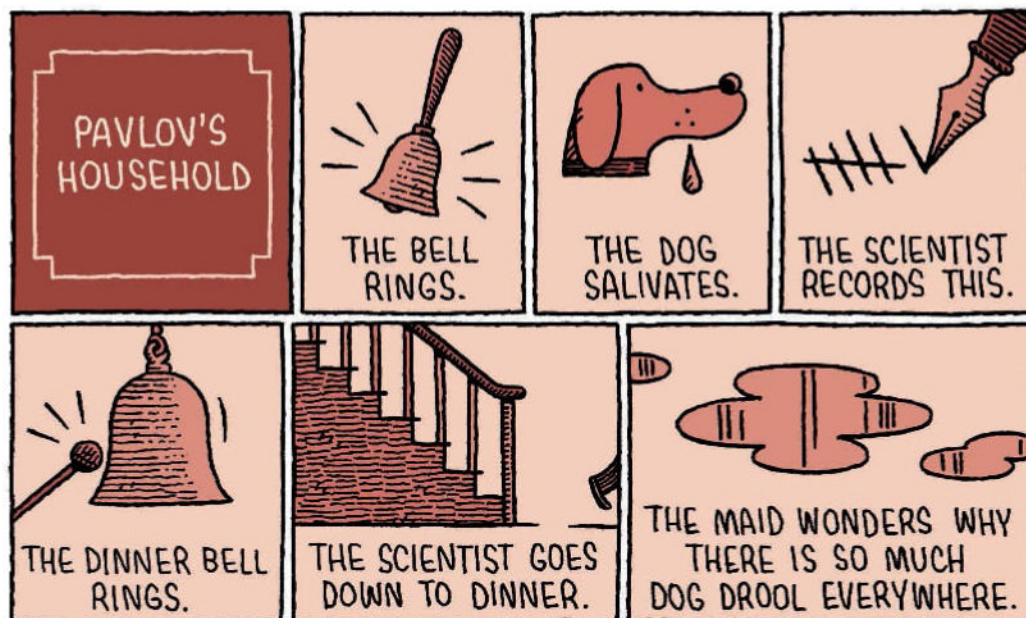
If you had claimed that the modal numbers were 8 and 12, rather than the means, that might have been more accurate. *Cambridge, UK*

Turn up the bass, Rheinmädchen!

From Bryn Glover

You report testing the impact of music on people’s ratings of how powerful, dominant and determined they felt (20 June, p 40). Had I been there, I would have rated boredom at the genres mentioned. Dennis Hsu and his team concluded that the presence of strong bass in the music induced a sense of empowerment: might I suggest the prelude to Wagner’s Das Rheingold? *Glasshouses, North Yorkshire, UK*

TOM GAULD



For the record

- It is the presence of nitrites in urine that could indicate a urinary tract infection (11 July, p 38).
- We're all in a spin. A pulsar emits radiation from its magnetic poles (4 July, p 10).
- Apologies: autism is not a psychiatric condition (27 June, p 38).

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PERPETUAL motion devices continue to deliver amusement, if not the promised free energy. Feedback previously discussed the Enclosed Loop Electric Windmill System, a device that raised \$3 of investment capital on crowd-funding site Kickstarter (18 July).

Imagine how delighted we are to discover that the charmers behind the Irish company Steorn are still cranking out promises of revolutionary free energy, almost a decade after challenging the scientific community to debunk their over-unity Orbo device. That challenge wasn't met – the fabled machine was never presented to the gathered experts – and a public demonstration of the technology at the Kinetica Museum in London likewise suffered “technical difficulties” and the demonstration

ended prematurely. Now Steorn is back, with the Orbo recast as a never-ending battery.

The device was given a “field test” in the august setting of Slattery's Pub in Dublin, where interested patrons could recharge their phones by connecting them to the block. Unfortunately this field trial proved too trying, and once again the demonstration ended prematurely. Further trials are purportedly taking place at undisclosed locations.

All of which shows that free-energy fruitloopery does seem to draw upon some inexhaustible resource – if only it could be tapped for useful power.

PREVIOUSLY Feedback touched on card clash – when the remote-sensing machines that administer our world are thrown into

confusion by the presence of too many contactless cards in one's hand (11 July). Jonathan Swan draws attention to a more fundamental problem: that “contactless card” is a clunky and cumbersome phrase.

“In more erudite times this would have been rendered in some form of Latin or Greek,” says Jonathan. “Using the standard Greek prefix ‘a-’ for without, and the Latin *tactus* for touch, could I propose the word ‘atact’ to describe this new technology?”

You may Jonathan, although blending Greek and Latin will have etymologists shouting at their televisions. Perhaps readers can come up with a suitable word?

THE fevered minds of futurists at KurzweilAI.net are agog at news that University of California researchers are working on “smart fabrics” that will adapt the wearer's temperature to the environment.

“Instead of heating or cooling your whole house, imagine a fabric that will keep your body at a comfortable temperature – regardless of how hot or cold it actually is,” they marvel.

Having thought for a moment, Feedback can imagine many such fabrics, and given the alternative is nudism, we're rather glad for them.

PERHAPS, like us, you are saddened that New Horizons – the plucky probe that just completed a historic Pluto fly-by, a journey 10 years in the making – will soon be lost to us forever as it hurtles into the emptiness of deep space.

Take comfort, then, in the knowledge that you could own a copy of the spacecraft – albeit one made of tiny plastic bricks. Space aficionado Luis Peña has designed a New Horizons kit for Lego Ideas, a site where the toy company kindly asks the public to submit models to be considered for commercial exploitation.

If his model receives enough votes it could make its way onto shelves – hopefully this version won't take a decade to arrive (bit.ly/nsLegoProbe).

MORE strange worlds: Feedback invites you to point your browsers to inkflash.com, the bookshop of the future, as envisioned in the late 1990s. Eschewing current design trends, inkflash plunges you into a crudely rendered 3D store, where you can pluck book-like objects off the shelves, just as if you were in a real shop. “Discover your next great read in a 3D labyrinth of book rooms,” the website invites visitors, somewhat unconvincingly.

A promised new feature, soon to arrive, will allow inkflash users to “read a whole book in 3D”. Which begs the question – isn't that what we've been doing all along?

FOLLOWING the illicit sale of Rubis the fluorescent sheep to an abattoir in France (11 July), Bill Tango brings news of more lab-based misdemeanours.

“In the 1960s when I was a student at the University of California, Berkeley, I occasionally



ate lunch in the Union cafeteria,” says Bill. “There was always a basket of hard-boiled eggs by the cashier. Some of them had numbers and letters written in pencil on the shells. I asked the cashier if she knew what the numbers meant. ‘No,’ she replied, ‘that's the way they are when they come from the virus lab’.”

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

“I know the book on nominative determinism is closed, sealed, and buried by now,” writes Stephen Murray, “but that your own magazine interviewed a William Hill about horseracing is surely worthy of some comment”

Seeds of doubt

Can anyone solve a mystery several decades old by identifying this seed pod (see photo)? It was collected on a beach just north of the town of Budva, in what is now Montenegro, in August 1967. A stream ran down to the beach from a marshy valley, and there were wooded hills on either side.

■ The mystery seeds are those of the Eurasian water chestnut, *Trapa natans*. I have seen it growing abundantly on Lake Skadar, which straddles the border between Montenegro and Albania, not far from Budva. The seeds are edible, but need to be boiled to remove a toxin.

The plant is sometimes called water caltrop, from medieval Latin *calcatrappa* (foot-trap): a reference to its pointed shape, which resembles the eponymous anti-personnel weapon that dates back as far as the 3rd century BC. Caltrops were cast on the ground to slow attacks using horses, elephants, camels or human troops. They continued to be used during the second world war against pneumatic tyres, with good effect.
*Harry Percy
Ludlow, Shropshire, UK*

"The seeds are the Eurasian water chestnut, which are edible but need to be boiled to remove a toxin"



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This week's questions

NETTLING CONUNDRUM

Can any readers identify this object (see photo) growing on a stinging nettle of the species *Urtica dioica*? The nettle was beside a gravel drive, and there are some small patches on the underside of the leaf ribs.

Elizabeth Herd

By email

No address supplied

WANING WOODPILE

Sometimes the wood at the bottom of our woodpile decays to the point where it has only a small fraction of its previous dry mass. What has happened to it? Where did all the carbon go? From the point of view of greenhouse gas emissions, is it better for the wood to be burned in my fire or for it all to rot back into the earth?

Peter Seligman

Victoria, Australia

HEAD SPACE

My thoughts feel as though they are in my head. Is there a physical basis for this, or is it just that I know that's where my brain is?

Julian Richards

London, UK

AIR DRUMMING

When I open my car windows while driving, everyone inside can hear a helicopter-like thumping sound. It is even worse when the rear windows are opened and it gets louder at



higher speeds. What causes this phenomenon?

Oscar Holroyd

Herefordshire, UK

DRYING DILEMMA

Which method of drying my hands uses less energy: an electric blow-dryer or a paper towel made of dried wood pulp?

Ian Cutter

Victoria, Australia

CHOC CHIP

Why does the chocolate on the outside of ice-creams and other frozen desserts always crack and fall into your lap when you bite into them? Why has science found no answer to this problem?

Volker Haupt

Vienna, Austria

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